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BOOK OF ABSTRACTS

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PREFACE

Cotton is an important fibre crop of India and the world as well. Indian farmers produce cotton ranging from coarse and shortest to finest and the longest fibre for all counts of spinning. There is hardly any scope of further expansion of area under cotton which calls for more attention towards improvement in productivity through conventional and unconventional approaches. The decreasing production and higher cost of production are thus, becoming a serious threat to cotton cultivation. The point of immediate concern, is to increase production by saving it from the onslaught of newly emerging pest complex.

Climate Change has become a major national issue as well as of global concern. New projections show that climate change and its consequences i.e. increased heat waves, melting glaciers, rise in sea level, change in temperature, ultra violet radiations, increasing carbon dioxide and other gases, depletion of nutrients in soil, erratic and scanty rainfall, declining water resources, changing pests-diseases scenario will affect every aspect of life. Such changes will affect cotton productivity and environment.

Cotton is one of the most ancient and very important commercial fibre crop of global importance with a significant role in Indian agriculture, industrial development, employment generation and improving the national economy. It is cultivated in tropical and sub-tropical regions of more than 100 countries. It is the back bone of the flourishing textile industry in India. Millions of people depend on cotton cultivation, trade, transportation, ginning and processing for their livelihood. India is the only country in the world growing all the four cultivated species of cotton alongwith their hybrid combinations.

Although India ranks first in area, its productivity is lowest among major cotton growing countries. The concerted research efforts in crop improvement and development of location specific crop production and protection technologies have increased cotton production. Presently, India is the second largest producer of cotton in the world, next only to China. Crop scientists have a crucial and pivotal role to play in solving the problems so as to benefit the poor peasantry.

The research papers included in the **"Book of Abstracts"** are related to **"Crop Improvement, Biotechnology and Post Harvest Technology", "Crop Production, Mechanization and Economic Development" and "Crop Protection and Biosafety"** which were the theme areas of the symposium. Present compilation on **"Future Technologies : Indian Cotton in the Next Decade"** is a compendium of holistic advancements and other relevant information related to cotton covering different disciplines. We hope that the information contained in this "Book of Abstracts" will be useful to all the stakeholders *viz.,* researchers, students, developmental officers, planners and farmers. We are thankful to the authors of individual chapters/papers for their contribution, time and diligence without which this volume would not have been possible.

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

Place: ANGRAU, Regl. Res. Station, LAM, Guntur

Dated: 17-12-2015

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1.1
Genetics of seed cotton yield and its component traits in cotton (*Gossypium hirsutum* L.)

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The present research work was carried out at Cotton Research Station, Junagadh Agricultural University, Junagadh during *kharif,* 2013 with a view to generate genetic information on gene effects for seed cotton yield and its component traits in cotton (*Gossypium hirsutum* L.). The experimental materials consisted of twelve generations, namely P_1, P_2, F_1, F_2, B_1, B_2, B_{11}, B_{12}, B_{21}, B_{22}, B_1s and B_2s of two crosses of cotton *viz.,* G.Cot 10 x MR 786 (Cross 1) and G.Cot 12 x GTHV 95/145 (Cross 2). Special scaling tests such as X and Y were significant either in cross 1 or cross 2 for all the four traits besides significance of other tests showing presence of epistasis. The $X^2_{(2)}$ value at six degrees of freedom were significant in all the traits in both crosses supported the presence of higher order epistasis. The $X^2_{(3)}$ value at two degrees of freedom was non significant in cross 1 for seed cotton yield/plant, bolls/plant and boll weight proving the ten parameter model as the best fit model. The $X^2_{(3)}$ value at two degrees of freedom was significant for all the four traits *viz.,* seed cotton yield/plant, sympodia/plant, number of bolls/plant and boll weight in cross 2 indicating the presence of higher order epistasis and/or linkage.

1.2
Inheritance of frego bract, okra leaf type and red colour leaves in cotton (*Gossypium hirsutum* L.)

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Inheritance studies of morphological characters in cotton are of considerable interest for genetic improvement. A thorough knowledge of the mode of inheritance of various characters help in solving the various breeding problems and in estimating the relative purity of hybrids and varieties. The present study was conducted department of Genetics and Plant Breeding, CCS HAU Hisar during 2013-2014 to study the inheritance of characters *viz.,* frego bract, okra leaf type and red colour leaves in cotton. In case of frego bract inheritance the genotype GCA 136 having frego bract was crossed with normal bract parent H 1098-i. In F_1 population all the plants were observed with normal bracts and in F_2 population normal bract and frego bract plants were in the ratio of 3:1 showing monogenic inheritance of the trait, frego bract being recessive. The test cross ratio of 1:1 confirmed the monogenic inheritance. For okra leaf type inheritance the genotype

GCA 278 with okra leaves was crossed with H 1098-i of normal leaves showed sub okra leaves in F_1 population. The segregation of the leaf shape in F_2 generation into three classes *i.e.* 1 normal: 2 sub okra: 1 okra was observed showing the incomplete dominance pattern of inheritance. In case of inheritance of red colour leaves the genotype GCA 289 with red leaves was crossed with green leaves parent H 1157 (female 223). In F_1 population plants with intermediate leaves towards redness were observed and in F_2 population 1green : 2 intermediate red : 1 red leaves plants were observed indicating the incomplete dominance pattern of inheritance.

1.3
Fidelity of interspecific cross in cotton for yield and fibre quality

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In recent year cotton is being a most popular cash crop ensured the economic returns. Fibre quality decides the textile demands. New technology now a days demanding good fibre quality especially fibre strength and length. It is an urgent need to have high yielding cultivars with better fibre qualities. The inter-specific three way cross between (*G. arboreum x G. anomalum)* x *G. barbadense* was made to introgress fibre strength from *G. anomalum* and fibre length from *G. barbadense*. The parents and thirty F_4 progenies were grown and used for present study. The genomic DNA was extracted and subjected to PCR amplification using fourty RAPD primers. These thirty progenies were grouped into high, medium and low fibre strength. The result revealed that, 36 primers showed polymorphism and total 541 amplicons were generated. Out of which 444 were polymorphic and 97 were unique bands with an average of 82.83 per cent polymorphism. The size of the amplification products ranged from 174 to 2752 bp. The unique bands may be species specific. The amplicons generated in *G. anamolum* was observed in segregating population, which may be associated with fibre strength. Similarly, it was observed in *G. barbadence* for fibre length. Thus this study confirm introgression of fibre quality in progeny of mentioned inter-specific cross in F_4 generation. This study confirms the inheritance of superior fibre quality characters from *G.* a*namolum, G. arboreum and* G. *barbadence* together in one *progeny*, which may fetch high prices to the farmers.

1.4
Extra long cotton genotype “Phule Rukhmai” (RHCb 011): Recommendation for central zone of India

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The overall mean performance indicated that genotype RHCb 011 (876 kg/ha) recorded 69.83 per cent higher seed cotton yield than the zonal check Suvin (516 kg/ha). The RHCb 011 was adjudged as the best entry in the five trials out of seven trials conducted at different locations in respect to yield and yield attributing characters. Likewise, this variety exhibited excellent fibre properties *viz.,* Ginning percentage (32.7), extra long fibre length (32.4mm), very good fibre strength (26.2 g/tex), fine micronaire (3.7), excellent uniformity ratio (51), very good maturity (>81) and excellent strength / length ratio (81per cent); which were suitable for extra long stable cotton. The genotype showed disease free reaction to gray mildew, moderately resistant to BLB and ALB, and tolerant to sucking peats and bollworm. Therefore, this genotype is recommended under the name ‘Phule Rukhmai’ for commercial cultivation in irrigated tract of central zone of India comprising Maharashtra, Madhya Pradesh and Gujarat state.

1.5
Genetic variability and heritability studies in cotton

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An experiment was conducted during summer 2014-2015 at Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri. Elevan genotypes were studied for variability, heritability and genetic advance for differant quantitative traits. From the results, it was observed that the differences between the genotypes were highly significant for the characters *viz*., seed cotton yield (kg/ha), lint yield, (kg/ha) and bolls/plant which indicates prersense of sufficient amount of variabilty.Similarly out of six characters, two characters showed wide range of variabilty *viz*., seed cotton yield (1381-2412) fallowed by lint yield (487-843) which indicates wide range of variabilty for this character and can be exploited through selection. From the variabilty parameters, it is observed that the character seed cotton yield (kg/ha) showed high gcv (11.17per cent) fallowed by bolls/plant (11.21), whereas the character number of bolls per plant recorded high h^2 (0.5713) coupled with high GA per cent of mean (57.13) fallowed by lint yield (32.74per cent) which indicated that these characters are under the influence of additive gene action and can be improved through simple selection.

1.6

Genetic analysis for variability and relationship studies for seed cotton yield and its yield attributing traits in *Bt* cotton hybrids (*Gossypium hirsutum* L.)

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The experiment was conducted during *kharif* 2014 at Regional Research Station, Anand Agricultural University, Anand to study the genetic variability, broad sense heritability, genetic advance and correlation among the eight traits and their direct and indirect effects on seed cotton yield by using path coefficient analysis. Indirect selection is a useful means for improving yield in cotton crop. With these objectives 56 *Bt* cotton hybrids were grown in randomized complete block design with three replications. The hybrids exhibited a considerable variation among all the traits. The estimates of PCV value were of higher magnitude than GCV for all the traits under study. The heritability estimates were found moderate to high for most of traits. Seed cotton yield was positively correlated with lint yield, bolls/plant, sympodia/plant and average boll weight at both genotypic and phenotypic level, which indicated that higher mean values for these traits can increase the seed cotton yield. Path coefficient analysis showed that lint yield, bolls/plant, sympodia/plant and average boll weight were major characters having positive direct effect and significant association with seed cotton yield. The information obtained from the current studies will be utilized in successful cotton breeding programme.

1.7

Heterosis and combining ability for seed cotton yield and its component traits of *desi* cotton (*Gossypium arboreum* L.)

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Line x tester analysis for heterosis and combining ability was attempted in 40 hybrids of *desi* cotton (*G. arboreum* L.) developed by using 4 lines and 10 testers. These were evaluated for seed cotton yield and yield components. The analysis of variance for combining ability for different characters expressed significant mean squares due to crosses and parents indicating that the hybrids and parents were significantly divergent in all the characters. The differences due to lines were highly significant for the

characters *viz.,,* plant height (cm), monopodia, bolls/plant and seed cotton yield/plant (g). Whereas, testers were highly significant for almost all the characters. The line x tester interactions differences were highly significant for all the characters except monopodia/plant. Out of 40 hybrids, 3 hybrids were heterotic and had positive and significant sca effects for seed cotton yield. The genotypes GMS 1, GAK 20, HD 450, HD 432 and HD 324 identified as good general combiner for seed cotton yield and other traits and are having better mean performance with high gca effects for seed cotton yield and most of the traits. The hybrids GMS 1 x HD 450, GMS 1 x GCD 22 and GMS 21 x P 541 registered high *per se* performance, coupled with significant heterobeltosis and sca effects in desired direction, can be considered for commercial exploitation.

1.8
Genotype x environment interaction studies in upland cotton (*Gossypium hirsutum* L.)

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Cotton (*Gossypium* spp) is the most important renewable natural fibre crop of global importance. Cotton production, processing and trade in cotton goods provide employment to about 60 million people in India. It provides fibre for textile industry, cellulose from its lint, oil and protein rich meal from its seed. Stability analysis plays an important role in knowing the suitability of the genotypes to variable environments. Efforts have been made to combine yield and performance stability into a single selection criterion. Hence the present study of stability was carried out in 45 hybrids of upland cotton in three locations *viz.,* Agriculture Research Station, Jangamaheswarapuram, Regional Agriculture Research Station, Lam and Agriculture Research Station, Darsi, of Andhra Pradesh during *kharif* 2013-14, with an objective to know the adaptability of genotypes to variable environments using Eberhart and Russell for quality traits. The experiment laid in randomized block design with three replications. Each plot consisted of two rows each of 6 m length with a spacing of 120 X 60 cm. Observations recorded on ten randomly selected plants for the following parameters 2.5 per cent span length, bundle strength (g/tex), fibre elongation (per cent), uniformity ratio, micronaire (10^{-6}g/inch) and seed cotton yield/plant (g). Analysis of variance revealed significant mean sum of squares due to genotypes and environment linear for all the characters. Pooled deviation was significant for all the characters. No stable hybrids were recorded for 2.5per cent span length. Twelve hybrids exhibited stable performance over locations for bundle strength. One hybrid, BBGH 77 x BBGH1 found to have stable performance over environments for fibre elongation ratio. Thirteen hybrids are to be considered to be stable performing across environments for uniformity ratio. Two hybrids BBGH 77 x BBGH 33 and BBGH 3 x GHL 5 considered to be stable across variable environments for micronaire.

1.9
Genetic analysis for seed cotton yield and its traits in American cotton (*Gossypium hirsutum L.*)

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Eleven parents were crossed using line x tester mating design comprising three lines and eight testers to estimate the combining ability and heterosis in *G.hirsutum* cotton for seed cotton yield, lint yield, ginning outturn, boll weight and seed index. Twenty four hybrids along with parents and check were evaluated during year 2013-2014 at Main Cotton Research Station, Navsari Agricultural University, Surat. ANOVA revealed significant differences due to treatments for all the characters under study. In case of line, differences were significant for ginning outturn, boll weight and seed index while in tester, differences were significant for lint yield , ginning outturn, boll weight and seed index. Ratio of gca/sca indicated preponderance of non additive gene action for all characters. Parents GSHV 158 and BS 27 identified as good general combiners for seed cotton yield and lint yield per plant. On the basis of specific combining ability and standard heterosis, the cross G.Cot 20 x GSHV 158 observed desirable for seed cotton yield and lint yield/plant and ginning out turn, while cross G.Cot 16 x RHC 0717 for seed cotton yield and lint yield/plant and seed index and cross GISV 272 x H 1454 was found superior for lint yield/plant, ginning outturn and boll weight.

1.10
Yield and fibre quality improvement for next decade by interspecific hybridization in cotton

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Cotton fibre is an important raw material for the textile industry and it plays a leading role in the economics of Indian agriculture as well as all over the world. Today's date though area under Indian cotton species was drastically reduced, the Indian species G. *arboretum* due to its wider adaptability, coarse and short fibre characteristics and high moisture absorbance, it will fetch greater export value in next decade under changing climatic conditions. It is highly demanded for spinning purpose as well as from the medical industry. Along with *G. arboretum* wild *Gossypium* species are also a rich source of fibre properties. Interspecific hybridization of cultivated *Gossypium* species followed by breeding could result in genotypes with improved characters for fibre properties. Attempt were made to transfer some of the fibre characters (strength) from *G. anomalum* and fibre length from G. *barbadense* into *G.arboreum* cultivated cotton for balancing of characteristics like high yielding ability, superior fibre properties and widwer adaptability by introgression of desirable characteristics between diploid and tetraploid cottons. In the present study,

F_4 and F_5 progenies of interspecific cross (*G.arboreum x G. anomalum*) x *G. barbadense* were evaluated for seed cotton yield, yield contributing characters, fibre quality traits for high spinning potential of the textile mills. On the basis of yield contributing characters and fibre properties twelve F_4 progenies and seventeen F_5 progenies were found to be superior and can be utilized for further utilization and improvement.

1.11
Exogenous GA_3 application for *in vivo* production of cotton inter-specific hybrid

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Cotton is one of the most important commercial crops of global importance and its demand is increasing day by day, both in national and international market. But, during growth period, it is affected by many pests, which induce different diseases that cause huge loss to cotton production. Diseases and pests resistance does not exist in tetraploid cotton germplasm at the present while the diploid *desi* cotton species have pest and disease resistance, drought tolerance and other favourable traits. Transferring these favourable genes from diploid species to tetraploid species of cotton by the traditional methods of emasculation and hand pollination is very difficult, due to the inability of the hybrid seed production. For supplementing boll maintenance and inter specific hybrid seed production, the gibberellic acid (GA_3) is generally found to play important role. Keeping the importance of GA_3 in view, this study was planned to determine the effect of GA_3 (0, 200 and 250 ppm) on the inter specific hybrids between tetraploid, H-1098i and diploid *desi* cotton, HD 432 during *kharif,* 2015. The H 1098i x H 1098i was also maintained for comparison. The cross included three treatments of GA_3 (50 flowers each): control, 200 and 250 ppm at 24 hrs after pollination.

The observations showed that H 1098i X H-1098i led to 28 per cent boll bearing with 16.8 fold seed setting/ boll (in comparison to H 1098i x HD 432) while in H 1098i x HD 432, it was 24 per cent in the absence of GA_3 treatment. Gibberellic acid was applied at 200 and 250 ppm concentration on H 1098i x HD 432 flowers, there was considerable differentiation in maintenance of bolls. The 200 and 250 ppm GA_3 treatment led to maintenance of 1.75 and 2.25 fold bolls, respectively in addition to three fold seed setting/boll in 250 ppm GA_3 application as compared with non-treated hybrids. The GA_3 application also resulted into increase in the fruit peduncle length in 200 ppm (17.08 mm) and 250 ppm (18.37) treated hybrids than that of the control (16.52 mm). The comparison of cotton treated with 250 ppm GA_3 and the control showed that application of this hormone dosage reduces the hybrid bolls falling ratio, considerably and can be used in cotton for producing inter specific hybrid seeds.

1.12
Performance of *Bt* cotton hybrids for yield and fibre quality characters under rainfed situation

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Most of *Bt* cotton hybrids, except inter-specific hybrids, belong to medium and long staple category. In India, *Bt* hybrids developed by different companies were approved by the GEAC for commercial cultivation. These hybrids are to be tested specifically for their performance in a given location for their adoption. Keeping this in view, a field experiment was conducted to evaluate sixty intra *hirsutum Bt* cotton hybrids including three *Bt* checks at Regional Agricultural Research Station, Guntur in *kharif* 2014-2015 in randomized block design with three replications. The analysis of data revealed significant differences between the *Bt* cotton hybrids for seed cotton yield. The seed cotton yield ranged from 1997 to 4054 kg/ ha , whereas, the hybrids PCH 9619 BGII (4054 kg/ha), NCS 8899 BGII (3998 kg/ha) and NCS 3133 BGII (3942 kg/ha) recorded significantly superior yield to *Bt* checks Bunny BG II (2477 kg /ha), Mallika BG II (3108 kg/ha) and Jaadoo BG II (3430 kg/ha). Highest boll/plant was recorded by PCH 9619 BGII (67) followed by NCS 8899 BGII (64). Boll weight ranged from 4.9 g to 6.8 g, number of bolls ranged from 30 to 67, 2.5per cent span length from 26.1 mm to 31.5 mm and bundle strength from 20.3 g/tex to 23.8 g/tex. KCH 3081 BGII 96.8 g) and JKCH 8905 BGII (6.8 g) recorded highest boll weight followed by JKCH 8935 BGII (6.7 g). Whereas, maximum 2.5 per cent span length was observed in Ankur 8120 BG II (31.5 mm) followed by NCS 234 (31.4 mm). Highest bundle strength was recorded by Ankur 8120 BG II 23.8 g/tex) followed by KCH 3051 (23.5 g/tex). In conclusion, it is clearly visible that some *Bt* hybrids are really performing better both in terms of yield and fibre quality characters in this environment.

1.13
Genetics of leaf curl virus disease (CLCuD) in cotton (*Gossypium hirsutum* L.)

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Cotton is an important *kharif* fiber cash crop, mainly grown for the lint. Cotton belongs to the genus *Gossypium* and family Malvaceae that comprises about 50 species globally. Cotton has high economic value as a fiber crop, grown in over 90 countries including India. During the growth period, cotton plants are attacked by a number of insects, pests and diseases, which reduces yield. Among diseases, Cotton Leaf Curl Virus Disease (CLCuD) is most severe and significant biotic constraint to cotton production across north western India, mainly in Haryana, Punjab and Rajasthan and its incidence frequency is also very high. The vector of this disease is white fly (*Bamicia tabaci*).Typical symptoms of CLCuD include upward/ downward leaf curling, stunted growth and 'enations'. Use of chemicals in controlling this disease is costly and not so effective. Moreover, enormous application of pesticides or other chemicals may impose hazards to human being and environment. Therefore, development of a resistant variety is most effective, long term, less expensive and safe method to fight against this disease and to enhance the productivity of cotton. Knowledge of the mode of inheritance of cotton leaf curl virus may play an important role in developing tolerant/resistant varieties. The present study comprises of two crosses between resistant and highly susceptible parents to cotton leaf curl virus disease involving H1353 (resistant), and HS 6 and RST 9 (highly susceptible). During *kharif,* 2013 and 2014, six generations namely P_1, P_2, F_1, F_2, BC_1 and BC_2 were generated for these crosses. All these generations were planted in RBD with three replications having two rows of each non-segregating generations (P_1, P_2, F_1), ten rows of segregating F_2 population, and four rows of each backcross (BC_1 and BC_2) for evaluation during *kharif*, 2015. Reaction of cotton leaf curl virus disease was scored (0-6 grade) on all the plants in all replications at different stages, that resulted into variation in disease incidence from plant to plant. The variation was also confirmed *via* biochemical estimations of total phenol and total sugar content at 60 and 90 days after sowing. The disease variation, thus observed, can further be analyzed for molecular pattern of inheritance.

1.14
Morphological characterization of *Bt* cotton hybrids

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Characterization and identification of genotypes is essential for their release, notification and seed production. Practically, a genotype must show distinct, uniform and stable characteristics that can be adopted for use in characterization and identification. The present study was undertaken for phenotypic characterization of most popular *Bt* cotton hybrids recommended for Haryana. The experimental material for the present investigation comprised of 28 *Bt* cotton hybrids of different companies, one non *Bt* check hybrid (HHH 223) with its parental lines and one non *Bt* check variety (H 1226). Experimental material was sown in the research area of the Cotton Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. Morphological characters namely flower petal colour, pollen colour, boll shape, leaf hairiness, plant growth habit, tip of the boll and position of stigma proved to be useful and stable as diagnostic traits to classify the genotypes based on the phenotypic traits.

1.15
Economic heterosis for seed cotton yield and contributing traits in upland cotton (G*ossypium hirsutum* L.)

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Hybrid cotton is a good approach for significant improvement in genetic potential for morph-yield and fiber quality traits. Heterosis works as basic tool for improvement of crops in from F_1 and F_2 populations and economic Heterosis contributes to choose genotypes with desired genetic variance, vigor and maternal effects over standard cultivar. Therefore it's essential to have detailed information about desirable parental combiners in any breeding programme, which can reflect a high degree heterotic response.

The present investigation was carried out during 2014 with 16 hybrids against one check HHH 223. The crosses were made during *kharif* 2013 at Cotton Research Area, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. All the sixteen hybrids along with check were sown in randomized block design with three replications in 67.5 x 60.0 cm. The data on yield and its attributing traits were recorded with objective to estimate the economic heterosis of hybrids. The hybrids namely, HHH 496, HHH 495 and GCA 101 x H1226 had sown maximum significant economic heterosis over check HHH 223 *i.e.* 25.09, 19.21 and 16.66per cent, respectively for seed cotton yield.

1.16
Dependency studies for morphological characters in upland cotton (*Gossypium hirsutum* L.)

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Cotton is prominent cash crop, playing a vital role in Indian economy. The fiber yield and quality of fiber is prominent criteria for selection in cotton. Correlation coefficients have been worked out for ten quantitative traits including fiber length and fiber strength in twelve elite genotypes of upland cotton (*Gossypium hirsutum* L.). The study revealed that traits *viz.,* bolls/plant (0.843), boll weight (0.626), lint index (0.269), seed index (0.245) and ginning outturn (0.084) were positively correlated with seed cotton yield based on morphological and quality data of twelve elite upland cotton genotypes. The traits *viz.,* monopodial branches/plant (-0.660), plant height (-0.360) and sympodial branches/plant (-0.346) were negatively related with yield. Fiber length (0.007) showed positivity whereas, fiber strength (-0.486) was negatively correlated with seed cotton yield. Correlation study is important asset for breeders, with the knowledge of extent of relationship/dependency between yield and quality characters contributing seed cotton yield facilitating in selection of desirable ideotypes in upland cotton.

1.17

Microsatellite marker based genetic diversity analysis and DNA fingerprinting of Indian cotton varieties

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Elite plant varieties form an important component of germplasm collections and provide a platform for future crop improvement programmes. Breeders develop superior plant varieties by systematic, scientific and pain staking efforts, investing valuable resources, time and intellect. Hence, they deserve protection being provided as plant breeders' rights (PBR) to prohibit unauthorized commercial exploitation of the variety. DUS traits based varietal characterization often does not provide fool-proof protection, hence molecular characterization becomes inevitable. Molecular marker based plant variety identification and differentiation is reliable and robust as these markers are abundant, polymorphic, genome-wide distributed and insensitive to environmental factors. In the present study, 12 cotton varieties developed by ICAR-CICR, Nagpur and 14 other popular cotton varieties developed by different AICCIP centres were profiled for DNA polymorphisms using 64 genome wide polymorphic SSR markers identified after screening more than 450 markers. Polymorphic markers detected 2 to 4 alleles/loci and majority of them had high PIC value indicating the high discriminating power of these markers. Utilizing the allelic profiles generated by these distinctly polymorphic markers, pattern of diversity was studied and varieties were clustered based on genetic distance. On an average, popular cotton varieties were found to be similar by more than 50per cent. Highest genetic similarity was found between CNHO 12 and Arogya, followed by Khandwa 2 and Khandwa 3. Highest genetic dissimilarity was noted between Surabhi and Suvin, followed by Suvin and AKH8828. SSR markers effectively distinguished varieties (capturing both inter and intra species variation) compared to DUS characters. A robust DNA fingerprint of 26 Indian cotton varieties was developed using selected set of highly polymorphic markers. Very low probability of identical match which is indicator of robustness revealed the potential utility of the DNA fingerprint developed in unambiguous identification of cotton varieties, their registration and protection under IPR regime.

1.18
Heterosis for seed cotton yield and its quantitative traits in cultivated upland cotton (*Gossypium hirsutum* L.)

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Cotton is a world's leading fibre crop and second most important oil seed crop. It is highly amenable for heterosis breeding. Commercial exploitation of heterosis in cotton has achieved a spectacular success in India. This study was undertaken to investigate the magnitude of standard heterosis for the characters of economic importance in cotton. Thirty nine hybrids along with check hybrid namely Bunny non *Bt* was grown in two row plot of 4.5 m length in randomized block design with two replications at Cotton Research Station, Srivilliputtur during summer 2015. The spacing adopted for the hybrid is 90 x 60 cm. The recommended agronomic practices and plant protection measures are followed as per the crop production guide for good crop stand. The highest standard heterosis percentage and mean performance was observed in H 16 (33.91per cent; 2686.8kg/ha) followed by H 15 (42.69per cent; 2649.9kg/ha), H 25 (42.45per cent; 2645.5kg/ha), H 24 (31.06per cent; 2433.8kg/ha). The highly correlated yield contributing traits such as number of sympodia, number of bolls and boll weight are useful for selecting the hybrids. The hybrid H 16 had significant positive heterosis and *per se* performance for boll weight (8.57per cent; 3.8), number of bolls (21.11per cent; 43.6), number of sympodia (18.52per cent; 22.4) and seed index (74.73per cent; 7.95); followed by the hybrid H 15 showed positive significant and mean performance for two characters namely bolls/plant (33.89per cent; 48.2) and seed index (62.64per cent; 7.4); the hybrid H 25 showed number of bolls (34.72per cent; 48.5), number of sympodia (14.81per cent; 21.7) and seed index (82.42per cent; 8.3) and the highest heterosis and mean performance for number of bolls (35per cent; 48.6), number of sympodia (33.33per cent; 25.2) and seed index (139.56per cent; 10.9) for the hybrid H 24. Hence, these hybrids H 16 (C 11-9 x Surabhi), H 15 (TCH 1705-169 x TCH 1608), H 25 (African I-2 x KC3) and H 24 (African I-2 x Surabhi) could be suggested for commercial exploitation of hybrids.

1.19
Studies on standard heterosis for yield and yield attributes in upland cotton (*Gossypium hirsutum* L.)

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Cotton is a crop of prosperity having a profound influence on men and matter is an industrial commodity of world wide importance. It occupies the place of pride in Indian Agriculture and economy by earning valuable foreign exchange. It provides employment opportunities to nearly 215 million people. Therefore, it plays a triple role by producing lint, oil and protein. Heterosis for seed cotton yield and yield attributing

characters in *Gossypium hirsutum* was studied involving eighteen hybrids along two checks namely RCH 2 and Bunny which were raised during summer 2015 at Cotton Research Station in two replications with spacing of 90 x 60 cm. The row length and rows per entry were 4.5 m and 2 respectively. The standard heterosis for seed cotton yield ranged from -40.01 (MCU 13 x GJHV 500) to 19.98 (SVPR 4 x GJHV 160) and seven hybrid showed the significant positive standard heterosis for seed cotton yield, for numbers of sympodial branches/plant, the standard heterosis ranged from -12.57 (H 99 x TCH 1732) to 20.57 (SVPR 4 x GJHV 160) and four hybrid showed the significant positive standard heterosis, for number of bolls per plant ranged from -28.34 (MCU 13 x GJHV 500) to 31.98 (SVPR 4 x GJHV 160) and eight hybrids exhibited significant positive heterosis for this traits. For boll weight, the standard heterosis was ranged from -18.06 (MCU 13 x GJHV 500) to 5.56 (BS 279 x LH 2256), for lint index, the standard heterosis ranged from -13.70 (BS 279 x GJHV 500) to 50.68 (MCU 13 x SCS 1001) and nine hybrids registered significant positive heterosis for this traits, for ginning percentage the standard heterosis ranged from -13.85 (BS 279 x GJHV 500) to 16.59 (RCH 2) and eight hybrids exhibited significant positive heterosis for this traits. Among the hybrids studied, the hybrid combination SVPR 4 x GJHV 160 had significant and positive standard heterosis for seed cotton yield, more sympodia branch and bolls/plant and hence it would be more desirable to exploit heterosis.

1.20

Heterosis studies for high ginning outturn per cent and related traits in *Gossypium hirsutum*

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Twenty seven agronomical high yielding parents (H 1098, F 1861, F 1378 9C, LH 2107, LH 2108, F 2164, F 846, LH 1134, CSH 3129, H 1226, IC 359508, IC 358382, IC 357203, IC 357671, IC 356665, IC 358479, SA-1231, IC 357726, EC359059, EC357032, SA 668, SA 524, Biyani 161, F2383, B 251, SA 112 and SA 977) of North Zone were used as female parent and 13 recombinant inbred lines of cross SA977xSA112 possessing high ginning outturn (GOT%) e" 40 were used as male to attempt crosses during 2013-2014 *kharif* crop season. 178 F_1 hybrids were raised in 2014-15 crop season in un-replicated trial to estimate heterosis over male, female and the best parent for the traits, Seed cotton yield (kg/ha), Boll no/plant, Boll weight (g), GOT per cent, plant height, monopod and sympod. Parent Biyani 251 and CSH 3129 in a cross with a recombinant line gave 17.25 per cent and 0.11 per cent heterosis, respectively for seed cotton yield (kg/ha) over the best parent. As many as 134 hybrids gave positive heterosis over male parent for this trait. For GOT per cent 15 hybrids gave heterosis higher than high GOT per cent male parent ranges from (0.22 to 6.00%) for boll no/plant positive heterosis was obtained for 8, 2 and 2 hybrids over the best female, male and the best parent respectively. 9, 27 and 9 hybrids exhibited positive heterosis over the best female, male and the best parent for the trait boll weight.

1.21

Performance of newly developed genotypes of *Gossypium hirsutum* for yield and fibre quality parameters under rainfed condition

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Twenty eight *intra hirsutum* genotypes with two checks were tested in randomized block design for yield and fibre quality parameters under rainfed conditions at Cotton Research Station, Nanded during 2014-2015. Seed cotton yield of genotypes was ranged from 284 (L 762) to 1156 kg/ha (GTHV 13/17). As many as five strains *viz.,* GBHV 183 (920 kg/ha), SCS 1061 (1105 kg/ha), GTHV 13/17 (1156 kg/ha), SCS 1207 (978 kg/ha) and RAH 1066 (1009 kg/ha) depicted significant superiority over zonal check, NH 615 (700 kg/ha). Ginning outturn was ranged from 27.56 (L 762) to 38.41 per cent (CPD 1452), the highest ginning percentage was recorded by the strain CPD 1452 (38.41%) followed by SCS 1061 (38.02%) and RAH 1066 (37.66%) 2.5 per cent span length of strains was ranged from 20.4 (NDLH 2010) to 30.7 mm (CCH 14-4). Fibre strength (g/tex) was ranged from 19.1 (CPD 1452, RAH 1003) to 26.6 g/tex (CCH 14-4)

1.22

Stability analysis for seed cotton yield and its component traits in upland cotton (*Gossypium hirsutum* L.)

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Yield is a complex trait, polygenic in inheritance, more prone to environmental fluctuations than any other characters. Genotype x Environment (GE) interactions are of major concern to plant breeders for developing improved cultivars. The presence of GE interactions reduces the correlation between phenotype and genotype and makes it difficult to judge the genetic potential of a genotype. In the presence of significant GE interaction, stability parameters are estimated to determine the superiority of individual genotype across the range of environments. The present investigation has been conducted with about 30 diverse elite breeding lines of upland cotton under three environments (early, timely and late sown) during kharif 2015. The observations were recorded for different traits namely, plant height (cm), bolls/plant, monopods /plant, sympods/plant, boll weight (g) and seed cotton yield/plant (g). Differential response of various genotypes over different environments and their stability for seed cotton yield were assessed.

1.23

Evaluation of *G. hirsutum* compact genotypes for high plant density under rainfed conditions

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An experiment for initial evaluation of twenty compact genotypes of *G. hirsutum* for high density were taken at cotton research station, Nanded during 2014-2015. The experiment was laid out in randomized block design with three replications. Three rows of six metres length of each genotypes with a spacing of 60 x 15 cm were sown. Check variety NH 615 was sown with 60 x 15 cm and 60 x 30 cm recommended spacing. Results were statistically significant for seed cotton yield. As many as seven strains *viz.*, DSC 1451 (447 kg/ha), GBHV 188 (503 kg/ha), ANGC 1451 (532 kg/ha), AKH 13 -51 (517 kg/ha), ANGC 1452 (629 kg/ ha), GSHV 171 (735 kg/ha) , GTHV 13/28 (560 kg/ha), DSC 1452 (489 kg/ha) and ARBC 1452 (491 kg/ ha) recorded significant superiority over local check, NH 615 (309 kg/ha) at closer spacing for seed cotton yield. The local check NH 615 recoded 41.74 per cent as increased seed cotton yield (309 kg/ha) over recommended plant spacing (218 kg/ha), the strain GSHV 171 (735 kg/ha) recorded highest seed cotton yield at closer spacing followed by ANGC 1452 (629 kg/ha) and GTHV 13/28 (560 kg/ha). Highest ginning percentage was recorded by strain ANGC 1452 (39.85 %) followed local check, NH 615 (37.00) at recommended spacing. Three compact strains *viz.,* GBHV 188 (27.3 mm), CNH 1121 (27.4 mm) and CCH 14-7 (27.6 mm) recorded better 2.5 per cent span length, were as micronaire was ranged from 3.1 (AKH 13-51, ARBC 1451) to 4.4 (CNH 1119). High tenacity was recorded by strain CCH 14-7 (22.9 g/tex)

1.24

Characterization of morphological traits for sucking pest tolerance in cotton (*Gossypium hirsutum* L.)

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Cotton has been principal commercial crop of India since time immemorial. The insect pests *viz.*, bollworms and sucking pests are the major yield limiting factors in cotton. *Bt* toxin expressed by *Bt* cotton is toxic against bollworms but not against sucking pests especially jassids and mirid bugs which have become

major pests in *Bt* cotton in India. Plant morphological traits like pubescence and bract type are important silent weapons and easily recognized to reduce this damage. With this back ground the present investigation was conducted to elicit the morphological characterization of hybrids and their parental lines for sucking pest tolerance. A total of 110 hybrids and its parental lines were screened for sucking pests under unprotected condition. Significant variation was observed for all traits, High variation and genetic advance was observed for the traits like pubescence scoring, jassid and mirid bug count. The pubescence related traits such as pubescence present on the abaxial leaf, bract, apical and lower portion of the stem showed significant positive association with boll weight and seed cotton yield .This may be because hairiness imparts resistance against leaf hopper thus less damage to the leaf as a result leaf area available for photosynthesis was increased, trichomes may also be effecting other unmeasured traits in cotton. This positive association clearly indicates that one can select for hairy cotton varieties for leaf hopper resistance, with no restriction imposed on yield. In contrast to this the correlation between bract pubescence and mirid bug infestation was observed to be negative. Therefore, it is necessary to breed cotton genotypes with leaf and stem pubescence to impart Jassid tolerance associated with open type of bracts with lower pubescence to impart Mirid bug tolerance. Detailed analysis resulted in identification of superior genotypes *viz.,* TCH 16781, DHS 10-18 and DHS T2 having higher pubescence on leaf with reduced pubescence on bract suitable for breeding programme for development of both jassid and mirid bug resistant genotype.

1.25

Conventional and molecular breeding approches for improving fibre quality in cotton

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The cultivated *Gossypium* spp represents the most important, natural fibre crop in the world. India is the only country cultivating all the four cultivated species of cotton. Breeding for high yield is still the primary goal of cotton breeding programs, but improving fibre quality has become increasingly important. The improvement in fibre quality traits like fibre length, strength, and fibre fineness is an essential requirement for the modern textile industry. Through a conventional breeding strategy, introgression of useful alleles for fibre quality from wild species and *G. barbadense* to *G. hirsutum* will be the effective way to improve the fibre quality traits. Fiber quality and yield are controlled by multiple genes that physically reside on chromosomes. Staple length, fiber fineness and fiber strength controlled by additive gene action with partial dominance while ginning outturn showed over dominance type of gene action. The predominance of additive gene action involvement in the phenotypic manifestation of the traits suggested selection as an accurate procedure for fibre quality improvement. The identification of the stable quantitative trait loci (QTLs) affecting fiber traits across different generations is helpful in molecular marker assisted selection to improve fiber quality of cotton cultivars. Simple sequence repeat and single nucleotide polymorphism markers will be developed using approaches such as genotyping-by-sequencing. Mutants, genetic mapping techniques and functional genomics analysis will be employed to identify the chromosomal locations of these genes. Cellulose biosynthesis and xyloglucan biosynthetic enzymes affect the development in cotton fibers. Members of cellulose synthase will be identified and analyzed through functional analysis using heterologous expression and virus induced gene silencing in *G. hirsutum*.

1.26

Conventional and molecular breeding approches for improving oil quality in cotton

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Oil content in cotton seed is a major quality trait which when improved through breeding could enhance the competitiveness of cotton seed oil with other vegetable oil. Cotton seed meal is used principally as a protein concentrate feed for livestock. Moreover cotton seed oil also has superior nutritive qualities; it has a 3:1 ratio of unsaturated to saturated fatty acids, which meets the recommendation of many health professionals. Cotton seed oil is rich in essential fatty acids such as palmitic and stearic (saturated), oleic and linoleic (unsaturated) acids. Cotton seed oil and protein concentration in cotton is controlled by multiple genes in the tetraploid embryo and tetraploid maternal plant genomes and strongly influenced by the environment. In biotechnological features of cottonseed oil and protein; the knowledge of quantitative trait loci (QTLs) and genetic mapping provides an essential tool for quantitative traits at the molecular level. Recently, DNA markers linked to QTL controlling kernel oil percentage, kernel protein percentage and amino acids was identified in cotton. These detected QTL for seed quality traits in cotton are expected to be useful for future breeding programmes targeting development of cotton with improved oil and protein content. To genetically modified the fatty acid composition of cottonseed oil using the technique of hairpin RNA mediated gene silencing to deregulate the seed expression of two key fatty acid desaturase genes ghSAD 1 and/or ghFAD2-1 enables the development of cottonseed oils having novel combinations of palmitic, stearic, oleic, and linoleic contents that can be used in margarines and deep frying without hydrogenation and also potentially in high-value confectionery applications.

1.27

Exploiting heterotic groups through reciprocal selection for combining ability to improve the performance of cotton hybrids (*Gossypium hirsutum* l.)

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The changing trends of clothing have always reflected the transformation and evolution of human civilization. Historically India has always played an important role in developments of cotton. India stands out as single largest country which has exploited heterosis in cotton to such a great extent. This unique feat is only possible in India because of intensive research on hybrid cotton, availability of labour for manual hybrid seed production *etc.,* The increase in competition among crops for commercial value has always raised the expectation of productivity of cotton hybrid.

Hybrid breeding program is supported by population improvement schemes aimed at improving combining ability in cross pollinated crops. There are very few studies on grouping genotypes based on heterotic pattern and exploiting them in self pollinated crops. At Dharwad efforts have made to identify different heterotic groups *viz.,* compact, stay green, robust and high RGR (High Relative Growth Rate) and their heterotic pattern *viz.,* stay green x compact, robust x compact, robust x higher RGR and stay green x high RGR which in general give potential hybrids.

In an attempt to exploit these diverse heterotic groups, attempts are made to enhance genetic distance between opposite heterotic populations following modified reciprocal recurrent selection scheme between opposite populations. The experimental material was constituted by heterotic box involving two diverse single crosses from opposite heterotic groups DSMR-10 x DSG3-5 (robust and stay green group) x DRGR 24-178 x DRGR 32-100 (high RGR group). Heterotic box was identified as base population through principle of predicted double cross performance and these two opposite base population were advanced to F_4 generation. Fifty lines each from these opposite crosses were randomly selected and utilized in assessing variability for combining ability against two reciprocal testers *viz.,* DSMR-10 and DSG3-5 (against high RGR F_4 Population and DRGR 24-178 and DRGR 32-100 against SG/Robust F_4 Population) ,one common tester (DH-2772) against both the population. An addition diverse robust tester DR-8 (against high RGR lines) and high RGR line DRGR 4 (against robust/stay green F_4 lines) were used to assess combining ability.

The crosses involving the F_4 lines with opposite testers were referred to as derived F_1s. These derived F_1s were compared with commercial check as well as bench mark cross. Ten elite combiner lines of high RGR cross DRGR 24-178 x DRGR 32-100 were identified based on performance of their derived F_1s involving reciprocal testers *viz.*, DSMR 10 and DSG3-5. Similarly ten elite combiner F_4 lines of robust stay green group of DSMR 10 x DSG3-5 were identified as the top ten combiners.

1.28
Morphological characterization of *desi* cotton elite germpalsm lines

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The varieties attain acceptance when the farmer gets genetically pure seeds of high standards. For this purpose, each cultivar should be properly defined with suitable descriptors, so as to maintain its identity during seed production through field inspection and certification. Apart from this, characterization of cultivars is also required for their protection under PPV and FR Act 2001. Present study was undertaken to characterize forty five elite germplasm lines of *desi* cotton during *kharif* 2015 season in Cotton Research area, Department of Generics & Plant Breeding under randomized block design (RBD) with row to row distance 90 cm and plant to plant 30 cm in three replications to study the morphological characterization. On the basis of plant hairiness characteristic 22 germplasms showed strong hairiness while 16 of medium hairiness. Green leaf colour was present in 20 genotypes while 16 genotypes were light red and 9 in light green category. Okra shape of leaf was dominant and it was present in 39 genotypes. On the basis of petal colouration, 17 genotypes were of cream coloured. In the present study petal spot was present in 42 germplasms. Out of total germplasm lines, 35 were having yellow pollen colour. Pitted boll surface was observed in 35 germplasms. Hypocotyl pigmentation was absent in 29 genotypes out of total germplasms. Twenty two germpalsms were of strong leaf pubscence while 20 with medium pubescence. Flower male sterility was absent in all the germplasms. Anther filament colouration was absent in 42 genotypes. Flower stigma was exerted in 42 genotypes while in three was embeded. On the basis of boll colouration, is generally green in 30 genotypes.16 round and 12 oval boll shape genotypes are observed.boll surface is pitted in 35 genotypes while smooth in 10 genotypes. Pointed boll was observed in 37 genotypes while it was blunt in 18 germplasms.

1.29

Heterosis for seed cotton yield and yield contributing characters over locations in upland cotton (G*ossypium hirsutum* L.)

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The present investigation was undertaken in hirsutum cotton by adopting line x tester analysis involving six diverse lines and nine testers. 54 hybrids (Six females and nine males) were developed. These hybrids along with parents and three checks PHH 316, NHH 44 and Bunny were planted in at different three locations. Observations recorded on 11 yield and yield contributing characters with an objective to estimate heterosis over better parent and three checks. The hybrid KH 121 x PH 348 had shown maximum significant heterosis over better parent (83.52 %), over PHH 316 (100.77 %), NHH 44 (51.75 %) and Bunny (75.33 %). This hybrid also showed significant heterosis for number of bolls per plant, boll weight and ginning percentage.

1.30

Stability analysis using AMMI model in cotton (*Gossypium hirsutum* L.)

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Cotton (*Gossypium* spp.) is the world's most important renewable natural textile fibre crop and is grown in diverse agro climatic regions. Sustainable cotton production requires identification and cultivation of stable cultivars and stability analysis plays an important role in knowing the suitability of the genotypes to variable environments. In stability models, Additive main effects and multiplicative interactions (AMMI) model has been revealed to be efficient because it captures a large portion of the GxE sum of squares and austerely separates main and interaction effects. The present study was conducted to determine seed cotton yield stability of 45 hybrids and to analyze the GxE interaction at three locations *viz.*, Agriculture Research Station, Jangamaheswarapuram, Regional Agricultural Research Station (RARS), Lam and Agriculture Research Station, Darsi of Andhra Pradesh State, India during the growing season of 2013-2014. AMMI analysis revealed that the major contributions to treatment sum of squares were environments (71.07%), genotypes (23.79%) and GxE (5.15%), respectively, indicating that the seed cotton yield of genotypes was under the

major environmental effects of GxE interactions. The interaction principal component 1 (IPCA1) contributed 74.26 per cent of the total GE interaction and was significant. The biplot technique results showed that the hybrids, BBGH 3xBBGH 26 (176.30g), BBGH 33xBBGH 1 (173.00g), BBGH 3xBGH 94 (166.00g), BBGH 1xBGH 94 (153.50g), BBGH 3xGHL 8 (141.00g) and BBGH 77xBBGH 26 (138.60g), are found to be stable with high mean value than general mean (138.80g) with zero IPCA1 score. The hybrids at Lam location showed high mean values with high interaction effects indicating the adaptability to specific environments. The hybrids at Jangamaheswarapuram and Darsi recorded low mean values with low interaction effects. The parents of these hybrids are transferred to the Principal Scientist (Cotton), RARS further characterization and registration before they are being exploited for commercial cultivation.

1.31

Development of cotton (Narasimha variety) transgenics for durable resistance against insect pest

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Cotton (*Gossypium hirsutam* L) is a commercial crop and plays an important role in textile industry and also as a source of cotton seed oil. The productivity of traditional cotton varieties is relatively low due to biotic stresses like insect pests, especially the broad spectrum lepidopteran pests like *Helicoverpa* and *Spodoptera*. The transformation of Indian elite cotton varieties like Narasimha remains a challenge due to lack of effective and reproducible transformation and regeneration protocols. In the current work, three Cry genes were pyramided under the regulation of suitable promoters in pMDC100 with *npt* II as selectable marker using gateway cloning strategy. This construct has been used to transform Narasimha variety using a non tissue culture based *in-planta* approach through *Agrobacterium tumefaciences* (LBA4404). The PCR analysis confirmed the presence and stable integration of *npt II* and three Cry genes in the transformants at T_1 and T_2 generations. The confirmed transgenic plants showed positive for immunochromatographic strip assay and all three cry proteins were detected in four T_1 plants. Phenotypic characterization and insect feeding assays will be carried out at T_2 generation. Improved transgenic lines could serve as a potential resource material in breeding for improving broad spectrum of insect resistant cotton lines in future.

1.32
Characterization of an interspecific hybrid between *Gossypium hirsutum* x *Gossypium armourianum*

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Interspecific hybrid between *G. hirsutum* cv F 1861 (AADD) and *G. armourianum* Acc PAU 1 (DD) along with parents were characterized at morphological and molecular levels. Female parent (F 1861) had erect growth habit, palmate leaves, green stem, cream petals, cream anthers, hairy stem and leaves; whereas male parent (Acc PAU 1) had spreading growth habit, yellow petals, cordate shaped leaves, greenish red stem, yellow anthers and glabrous plant body. The growth habit, petal colour, leaf shape and size of the interspecific F_1 hybrid were found to be intermediate. Plant stem coloration, stem hairiness, leaf pubescence, and anther colour of *G. armourianum* Acc PAU 1 were observed to be dominant as hybrid fully resembled the male parent for these characters. Three bracts having normal shape with long teeth like serrations were present in case of female parent and the hybrid. Male parent had caduceus bracts *i.e.* it shed before opening of the flower. However, in case of hybrid, bracts shed before the opening of the boll but were present on the flowers. Dark pink petal spot was present in Acc PAU 1, whereas it was absent in F 1861. In the interspecific hybrid, wide range of petal spot and filament colour, in terms of size and intensity, was observed in different flowers of the same plant. Variable expression in F_1 suggested the role of epigenetics in the expression of these characters. The interspecific F_1 hybrid was highly male-sterile with 2.19 per cent pollen fertility. Significant differences were observed between the pollen size of the parents as well as parents and their hybrid. Eight SSR markers namely BNL 3590. BNL 3917, BNL3948, NAU1070, NAU 2156, NAU3561, NAU3775, and NAU5345 unambiguously confirmed the hybrid status of interspecific hybrid at molecular level. The hybrid was observed to be resistant to cotton leaf curl disease like its male parent *G. armourianum*.

1.33

Interspecific hybridization between *Gossypium hirsutum* and *Gossypium arboreum*

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Hybridization was attempted between nine accessions of *G. hirsutum* and five accessions of *G. arboreum* in different combinations to develop interspecific hybrids through *in ovulo* embryo culture. A mixture of growth regulators (GA_3 @ 50 ppm + NAA @ 100 ppm) was applied at base of pedicel of crossed buds for three successive days starting from day of pollination. The hybrid bolls were harvested three days after pollination and excised to culture the ovules on the nutrient medium. In *G. hirsutum* x *G. arboreum* crosses, boll retention three DAP ranged from 54.54 per cent (LH 900 x LD 949) through 82.90 per cent (PIL 43 x FDK 124) with mean value of 75.06 per cent. Of the 26,300 ovules cultured, 33 germinated with germination percentage of 0.12. Embryo germination was observed in seven crosses, namely, LH 2108 x LD 327 (0.57%), F 2164 x LD 949 (0.33%), F 2164 x FDK 124 (0.30%), PIL 43 x LD 949 (0.083%), LH 2108 x LD 949 (0.066%), LH 2108 x FDK 124 (0.044%), and LH 1556 x LD 491 (0.083%). Of the ovules cultured in MS + 0.2 mg/l TDZ medium, two ovules of the cross F 2164 x FDK 124 (0.39%) germinated. In MS + Gamborg's B5 vitamins + 1.9 g/l KNO_3 medium, 11 ovules of six different crosses, viz., LH 2108 x LD 949 (1), LH 2108 x LD 327 (2), LH 2108 x FDK 124 (2), F 2164 x LD 949 (1), F 2164 x FDK 124 (3), and PIL 43 x LD 949 (2) germinated, with germination percentages of 0.31, 0.33, 0.32, 0.09, 0.48, and 0.42, respectively. In media composition MS + 1.0 mg/l IAA + 0.2 mg/l Kin, 19 ovules of LH 2108 x LD 327 (12) and F 2164 x LD 949 (7) germinated, with germination percentages of 0.75 and 0.40 respectively. One ovule of the cross LH 1556 x LD 491 germinated in the medium, with a germination percentage of 0.083. American cotton varieties namely, LH 2108 and F 2164 were observed to give higher embryo germination when used as female parents. Hybridity of the interspecific hybrid between LH 2108 x LD 327 was confirmed employing microsatellite markers.

1.34
Creating genetic diversity through hybridizing diverse parents in American cotton

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Variability is one of the basic requirement for initiating a productive breeding programme for combining desirable genes from diverse sources either in hybrids or segregating generations following intervarietal hybridization. The creation of genetic diversity through hybridization is the starting point of another cycle of crop improvement using different mating designs in a breeding programme. To evaluate genetic diversity in a set of 194 recombinant inbred lines (RILs) of American cotton derived from a cross between RS 2013 and P 56-4 , the plant material was raised in partially balanced lattice design with two replications at Faridkot during 2014-2015. The data were recorded on five randomly taken plants for seed cotton yield/plant (g), lint yield/plant (g), ginning outturn (%), bolls per plant, boll weight (g), seed index (g), lint index (g), plant height (cm), monopods/plant, sympods/plant, 2.5 per cent span length (mm), micronaire value and fibre strength (g/tex). To study diversity among the lines, data were analysed using Mahalanobis's D^2 statistics. The RILS and parents were grouped in different clusters according to Toucher's Method. Analysis of variance for all the traits revealed significant differences among the 194 RILs and two parents. D^2 values ranged from 6.24 to 4943.23 indicating substantial genetic diversity in the material evaluated. Parental lines and 194 RILs were classified into five clusters. Cluster I, the largest cluster with 135 genotypes included parent RS 2013. Cluster II included 38 RILs and Cluster III included 20 RILs and another parent P 56-4, whereas Cluster IV and V included one RIL each. Both the parents were included in different clusters suggesting that these were genetically diverse, one of the criteria for initiating any crop breeding programme. The intra-cluster distance was maximum for Cluster II (257.17) and minimum for Cluster I (175.04). The inter-cluster between Cluster II and Cluster IV (3128.81) was maximum and minimum between Cluster II and Cluster V (341.12). A perusal of the results revealed that sufficient genetic diversity has been created through the hybridization of two diverse parents, RS 2013 and P 56-4 which can further be used by the selection of parents for hybridization from two clusters having wider inter-cluster distance so as to get more transgressive segregants or heterotic cross combinations.

1.35
Heterosis and combining ability in American cotton (*Gossypium hirsutum* L.)

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India is a pioneer country for commercial cultivation of hybrid cotton since 1971. Hybrid cultivation offers scope for high yield and stability production. Knowledge of combining ability is useful for selection of desirable parents for exploitation of hybridity and tansgressive segregants and provide sound basis for parental selection. The present study was undertaken to identify the promising hybrids based on heterosis and find out combining ability effects of parents. The experimental material encompassed fifty six upland cotton hybrids developed by crossing fourteen males with four females in a line x tester mating design during kharif 2013 plus one standard check (HHH223). The hybrids were evaluated at CRS, Sirsa during 2014.The standard heterosis of hybrids was calculated and combining ability worked out.
Heterosis for seed cotton yield ranged from -40.75 to 70.64 per cent. Highest heterosis was obtained for the hybrid H1098 x Pusa 864 followed by H1098 x La fregobract (61.48%). For bolls per plant heterosis ranged from -30.24 to 43.01 per cent and for boll weight heterosis ranged from -14.1 to 16.2 per cent. For number of monopods and sympods heterosis ranged from -69.84 to 74.60 per cent and -24.51 to 28.17 per cent respectively. The range was -9.11 to 6.38 per cent for GOT. Variances due to gca were higher than sca indicating the pre dominance of additive type of gene action in the inheritance of these characters. Female H1098 was found to be the best general combiner for seed cotton yield/plant. Among males PIL 8-5 followed by Gregg 45 obtained high gca effects for yield. Gregg 45 for number of monopods, HS20 for sympods, SV213 for number of bolls, Pusa 864 for boll weight and La fregobract was found to be best general combiner for GOT. Thus these parents can be used in further breeding programmes. Specific cross combinations obtaining higher cotton yield/plant were H1300x FSS and H1300x Pusa 864.

1.36
SV 385: A high yielding and non shedding genotype of *desi* cotton (*Gossypium arboreum* L)

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Shedding of *kapas* is a main problem in *desi* cotton, hence development of non-shedding, high yielding, early maturing and stable genotypes will overcome the solution. Accordingly, genotype SV 385 was developed. This genotype has almost 100 per cent non shedding of *kapas* up to the last boll opening. It matures in 150-

155 days and last picking is over by the end of September. Adaptability to change in agronomic conditions, SV-385 gave significantly higher seed cotton yield at all the locations of north and central zone states. The per cent increase in yield was recorded14.1-25.8 at different locations. The row spacing of 90x30cm was found to be optimum. Among the fertilizer doses 100 per cent RDF gave higher seed cotton yield. It is found resistance to lodging, shedding and responsive to fertilizer doses. However, SV 385 was found resistant to bacterial leaf blight disease, comparatively tolerant to Fusarium wilt, root rot and fungal foliar leaf spot diseases and tolerant to jassid and bollworm as compared to check varieties. It is suitable for cotton raya cropping system as well as timely and late planting under irrigated conditions with required seed rate of 3.5-4.0 kg/ha**.** SV-385 has a plant height ranging from 180-190cm. Plant is erect, spreading with narrow lobed digitate leaves, nectarines present on leaves, yellow coloured petals with dark red spots at the base, exerted stigma, anther filament colouration present and yellow coloured pollen. It has elliptic boll shape, pitted surface, pointed prominence of tip, large boll size with 3.5-4.0g boll weight. Ginning outturn is 42 per cent with medium fuzzy grey seed, white fibre colour and desired fibre properties. Variety SV 385 has total balance of traits that makes a variety more profitable to farmers. It has high yield potential coupled with early maturity, non shedding, amenable to different sowing situations and better disease resistance. These qualities will optimize the yield and gives maximum economic return to the farmers of the states of Punjab, Haryana, Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujrat and Maharashtra.

1.37
Current scenario of cotton in Telangana state

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The cotton area and production has shown significant improvement over the past few decades. From over six lakh ha in 1990, the cotton area has increased to 16.51 lakh ha (2014-2015) and production risen to 50 lakh bales (2014-2015). The productivity has also reached to about 520 kg lint/ha (2014-2015). Cotton is grown predominantly in Adilabad, Karimnagar, Warangal, Khammam and Mahaboobnagar districts of Telangana state. Majority of the cultivated hybrids are of Intraspecific *hirsutum* hybrids. The area under *hirsutum* and *arboreums* are concentrated in Adilabad district. *Bt* cotton hybrids like Bunny *Bt*, Mallika *Bt* and Tulasi *Bt* are popular and are grown in sizeable areas. Of the total cotton area, around 25per cent is under irrigated situation. Multiplicity of cotton hybrids, spurious seeds, extensive use of poor quality and adulterated insecticide chemicals and pesticide use are the major problems in Telangana state. The other major drawback is overdose of chemical fertilizer application and monocropping of cotton practiced by cotton farmers. Extensive use of pesticide chemicals right from the seedling stage disturb and annihilate the parasites and predator population, leaving cotton to serious sucking pests like aphids, jassids, thrips and whitefly. Hence, appropriate remedies like Insecticide Resistance management strategies, Integrated Pest Management, Integrated Nutrient Management besides scientific methods of weed control and water management will play an important role in enhancing the cotton productivity at farmer’s level.

1.38
Culinary and medicinal uses of cotton

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Byproduct utilization for food, medicine and manure provides additional income generation and employment. Fibre is the main product of cotton predominantly used for apparel and surgical purposes. We used ‘Charkha’ in childhood and prepared wicks by hand for devotional purposes followed by feeding cotton seed (important byproduct) to cattle, especially cows as gossypol is less toxic to ruminants. We tasted sweet made of cotton milk, prepared by soaking seed, grinding, boiling and straining, in Madurai (Rupees 10 for cup of 100 ml). Though we use cow ghee and gingelly oil for lighting lamps during daily worshipping and festivals, we observed that crude cotton oil is more economic. Elimination of gossypol problem by RNA gene silencing made 23per cent protein of cotton seed available.
Being scientists, we do thinning in our experiments and rouging in seed production plots. An attempt was made to cook twigs, immature leaves and mature leaves obtained from thinned plants. Twigs and immature leaves having more hairs are more astringent than mature leaves. Tender leaf chewing refreshed mouth and stopped bad breath as mentioned in Ayurveda which prescribes leaf paste, decoction of twigs, paste and juice of flowers, decoction of petals, chewing root bark, tea by brewing root, seed paste, oil for various ailments. Traditional herbal medicines are experience based where as modern medical research demands experimental evidence. Tradomedical research is needed for authenticity and publicity of indigenous technology and knowledge. Nevertheless, *in situ* incorporation of cotton residue enriches the soil fertility. *Vermi* composting and mushroom production will be more beneficial.

1.39
Comparative study of *Bt* cotton hybrids under rainfed condition

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A comparative study of performance BG II *Bt* cotton hybrids in relation to seed cotton yield and other characters was carried out at Cotton Research Unit, Dr. PDKV, Akola. Total 68 BG II *Bt* cotton hybrids of different seed companies were evaluated in five different trials with three checks in RBD with three replications during 2014-2015. The statistical difference was significant for seed cotton yield in all five trials. In first trial *Bt* cotton hybrid NCS 1818 BG II recorded highest seed cotton yield (1015 kg/ha) followed by NCS 3456 BG II (937 kg/ha) and NCS 7788 BG II (902 kg/ha) whereas in second trial *Bt* cotton hybrid ACH 151-2 BG II exhibited highest seed cotton yield (1311 kg/ha) followed by PCHH 6 BG II (1296 kg/

ha) and PCHH 4 BG II (1175 kg/ha). The *Bt* cotton hybrid NCS 6566 BGII recorded the highest seed cotton yield (1026 kg/ha) followed by SP 7149 BG II (1011 kg/ha) and PCH 9605 BGII (999 kg/ha) in trial III whereas, the *Bt* cotton hybrid SRCH 402 BGII exhibited highest seed cotton yield (1347 kg/ha) followed by western kasuri 666 BGII (1334 kg/ha) and Western Kasuri-666 BGII (1178 Kg/ha) in trial IV. The *Bt* cotton hybrid NBC 102 BGII recorded the highest seed cotton yield (1154 kg/ha) followed by ACHH 57 BGII (1096 kg/ha) and NBC 101 BGII (967 kg/ha) in trial V.

1.40

Stability of combining ability for yield, yield contributing characters and fibre properties in cotton (*Gossypium hirsutum* L.)

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The present investigation was undertaken to evaluate combining ability of 7 lines, 9 testers and their 63 hybrids over three environments replicated twice to study the stability of gene action. All the genotypes evaluated in *kharif* 2014 at 3 locations and data was recorded on 23 different parameters. Among the lines NH 615 was found significant for first boll burst, 50 per cent flower and boll burst, all the yield contributing characters, yield, ginning outturn, upper half mean length (UHML) Uniformity index and fibre strength pooled over environments. Among testers PH 348 was significant for all the yield and yield contributing characters followed by NH 635 which in addition was also significant for UHML pooled over environments. Among the crosses DHY 286-1 x PH 348 was found significant for days to first flower, 50 per cent flower,plant height, internode length, node number, days to 50 per cent boll burst, yield and yield contributing characterswith high mean in desirable direction for these characters pooled over environments which can be used for direct use as a hybrid. Cross NH 615 x NH 635 have shown high mean in desirable direction for most of the earliness traits, yield contributing characters and fibre properties with non significant SCA effect pooled over environments having both of the parents with significant GCA in desirable direction indicating the preponderance of additive gene action for these characters which can be used for pedigree selection. All this crosses shown high mean with regression coefficient near to unity and non significant deviation from zero.

1.41

Estimation of genetic parameters through generation mean analysis in cotton (*Gossypium hirsutum* L)

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The experimental material comprised of P_1, P_2, F_1, F_2, BC_1 and BC_2 sixgenerationsofthree crossesAK-32 x DHY-286-1(AKH Hy 2), BN-1 x AC-738 (NHH44) and NH-615 x NH-625(NHH206). Both main and epistasis gene actions were important in inheritance of yield and yield contributing traits. Predominance of dominance gene action observed for the most of the characters under study. The duplicate type of epitasis further confirms the prevalence of dominance gene effects. Additive (d) gene action was important in the inheritance of days to first flower and days to 50% flower and micronairvalue. In case of seed cotton yield both main gene action (d and h) play an important role in inheritance of this character. In general, additive x additive (i) gene action has enhancing effect in expression of all the twenty one characters under study.

1.42

Assessment of genetic variability, correlation and path analysis for yield and its components in *Gossypium barbadense,* L. genotypes

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The present study was carried out to determine the genotypic, phenotypic correlation coefficients and path analysis at the genotypic level between seed cotton yield, yield contributing traits, earliness, fiber quality parameters in 15 genotypes with control variety Suvin of *Gossypium barbadense,* L.,with The experiment was designed as RBD with three replication and conducted during 2012-2013 *kharif* season. The results revealed that phenotypic coefficient of variation (PCV%) was higher in magnitude than the genotypic coefficient of variation (GCV%) for all the traits studied. Heritability revealed higher estimates of seed cotton yield kg/ha (93%), boll weight (89%), fiber length (87%), fiber strength (86%), fibre fineness (84%) plant height (83%), bolls/plant (81%), days taken to 1st flower (77%), Days taken to 1st bud (76%) while for nodes to 1st fruiting branch (55%), staple length (51%), monopodia/plant (52%) were moderate but low estimates were found in GOTper cent (33%) sympodia/plant (31%). With regards to correlation studies, seed cotton yield had only positive genotypic association with bolls/plant, boll weight (g), plant height and sympodia/plant. Path coefficient analysis results revealed that all the traits indirectly influenced the seed cotton yield. The traits like days taken to 1st bud, days taken to 1st flower, nodes to 1st fruiting branch,

may be considered for selection of the early maturing genotypes as they showed higher estimates of heritability along with positive and significant genotypic correlation with seed cotton yield.

1.43

Effect of environment on crop phenology, development and yield in *Bt* and non *Bt* cotton hybrids

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To assess the impact of climate change on cotton, an experiment was conducted at Cotton Research Station, Nanded during 2012-2013, 2013-2014 and 2014-2015 comprising of seven *Bt* and non *Bt* cotton hybrids with two sowing dates. On an average of three years data, normal sowing (1030 kg/ha) of cotton genotypes were found superior over late sowing (630 kg/ha) in terms of yield and yield contributing characters. However, the *Bt* cotton hybrids *viz.,* NCS145 and Ankur 3028 recorded significantly highest seed cotton yield 1289 kg/ha and 1290 kg/ha respectively in normal sowing. Whereas, in late sowing condition, the non *Bt* hybrid recorded significantly highest seed cotton yield ranges 844-608 kg/ha against *Bt* cotton hybrids ranges 493-438 kg/ha. There is more reduction in yield of *Bt* cotton hybrids as compared to non *Bt* cotton hybrid in terms of number of bolls/plant. Duration of 50 per cent boll opening is more in normal sowing D_1(145 days) as compared to late sowing D_2 (135 days). Duration of 50 per cent boll development is also more in normal sowing D_1 (119 days) as compared to late sowing D_2 (110 days) indicating more duration of boll development in normal sowing than late sowing. The growing degree days (GDD) occurred as affected by environments are 2830^0C-d in normal sowing and 2658^0 C-d in late sowing. It is clearly indicated that the GDD is higher than 1800^0 Cd, which is above normal cotton crop production occurs due to increase in temperature. Overall, the non *Bt* cotton genotypes recorded the highest seed cotton yield and other yield contributing traits in late sowing condition as compared to *Bt* cotton hybrids.

CROP PRODUCTION, MECHANIZATION AND ECONOMIC DEVELOPMENT

2.1
Productivity of *Bt* cotton hybrids in relation to plant density and nutrient management under delayed monsoon condition

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A field investigation was conducted during the rainy season of 2014-2015 on vertisol to study the productivity of *Bt* cotton hybrids in relation to plant density and nutrient management under delayed monsoon condition. The experiment was laid out in split plot design replicated thrice. Among the three *Bt* cotton hybrids, Deltapine 1937 (Monsanto), Balwan and Ankur 3028. Deltapine 1937 (Monsanto), showed better growth and recorded significantly higher values of plant height, number of picked bolls/plant, boll weight and seed cotton yield. Wider plant spacing of 90 x 45 cm^2 (24691 plants /ha) showed higher values against the closer plant spacing of 90 x 30 cm^2 (37037 plants /ha). Higher fertilizer application at the rate of 150per cent RDF recorded significantly higher values as compared to 100 per cent and 125 per cent RDF.

2.2
Effect of herbicides on growth, weed control efficiency and seed cotton yield of HDPS cotton

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A field experiment was conducted during the rainy season of 2014-2015 on vertisol, to study the effect of different pre- and post-emergence weedicides on high density planting system (HDPS) cotton among the tested weedicides, the highest seed cotton yield (1741 kg/ha) was recorded with weed free check followed by pendimethalin 38.7 EC PE @ 1.25 kg a.i./ha *fb* hoeing at 30 DAS and one hand weeding at 45 DAS. The highest weed-control efficiency (96.08) was recorded with weed free check followed by pendimethalin 38.7 EC PE @ 1.25 kg a.i./ha *fb* hoeing at 30 DAS and one hand weeding at 45 DAS. The SCY was maximum due to more number of plants of AKH081/unit area. The plant population was 1.55 lakh /ha sown on broad bed furrow system.

2.3
Designing low cost drip irrigation system for cotton by adopting plant geometry engineering

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In India, for the past three decades research has been intensified in drip irrigated cotton. But the area under drip irrigated cotton had not registered the expected increase. The main reason for the relatively restricted use of drip irrigation in cotton is the high initial cost. Possible solution for reducing the drip irrigation system cost includes wider spacing of laterals. With the above background field experiments were conducted to study the effects of lateral spacing with altered plant geometry and density on cotton yield and economics at Agricultural College and Research Institute, Madurai. The experiments were laid out in FRBD with three replications using cotton hybrid RCH 2. The combinations of plant geometry, lateral spacing and plant density included, normal geometry (every row lateral spacing and low plant density), paired row geometry (wider lateral spacing and low plant density), intra row increased geometry with 2 plants hill [1] (every row lateral spacing and high plant density), triple row geometry (wider lateral spacing and high plant density) and rectangular geometry (wider lateral spacing and high plant density). Under every row lateral spacing, one lateral was designed for every crop row at spacing of 120cm, whereas in wider lateral spacing, one lateral was designed for every two crop rows at spacing of 240cm. Low and high plant density accommodated 13889 and 18518 plants /ha . Two drip irrigation fertigation regimes (100 per cent ETc + 100per cent N and 75per cent ETc + 75per cent N) were evaluated. Rectangular geometry (wider lateral spacing – 240cm + high plant population 18518 plants /ha) recorded comparable seed cotton yield and gross income with normal geometry (every row lateral spacing 120cm + low plant population 13889 plants /ha) with lesser capital cost on system layout. Thus higher net income and B: C ratio and lower pay back period were registered by rectangular geometry with a saving of Rs. 34600 on capital investment on drip irrigation system. Thus rectangular geometry (wider lateral spacing 240cm + high plant population 18518 plants /ha) may be recommended as a low cost drip irrigation system design for cotton farming.

2.4
Site specific nutrient management in *Bt* cotton under Tungabhadra command area of Karnataka

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Cotton is the most important commercial fiber crop cultivated in diverse agro-climatic situations in India. *Bt* cotton is an exhaustive crop and needs more nutrients to attain a higher yield. Further, nutrient recommendation differs with crop response, genotypes, soil and climatic conditions. Site specific nutrient

management (SSNM) which suggests need based supply of nutrients ensures application of nutrients at right time in desired quantities for the crop to obtain set target yields. Besides, omission of any nutrient in crop growth also shows its role in limiting the crop yield. Hence, a field investigation was carried out to study the site specific nutrient management in *Bt* cotton under irrigated ecosystem at Agricultural Research Station, Siruguppa, during *kharif* 2008-2009 on deep black soil with available nitrogen, P_2O_5 and K_2O of 195.7, 15.5 and 430.1 kg/ha, respectively. The experiment was laid out in a randomized block design with three replications. The experiment consisted of eleven treatments *viz.,* T_1: Absolute control (No fertilizers), T_2: Nutrients for 30 q/ha yield targeted (135: 75: 150 N-P_2O_5 and K_2O kg/ha plus macro and minor nutrients), T_3: T_2 minus N, T_4: T_2 minus P, T_5: T_2 minus K, T_6: T_2 minus Ca, T_7: T_2 minus Mg, T_8:T_2 minus S, T_9: T_2 minus Zn, T_{10}: T_2 minus Fe and T_{11}: T_2 minus B. The hybrid used in experiment was RCH 2 *Bt* BG II with spacing of 90 x 60 cm. The experimental results revealed that, application of nutrients for 30 q/ha targeted yield (135:75:150 N, P_2O_5 and K_2O kg/ha plus macro and minor nutrients) registered significantly superior seed cotton yield (2942 kg/ha) with higher gross, net returns and B:C ratio of Rs. 76501/ha , Rs. 54014/ha and 3.40, respectively as compared to without nutrient application (T_1), N omission (T_3), P omission(T_4) and K omission (T_5) treatments. Significantly lower seed cotton yield (1552 kg/ha), gross return (Rs.40361/ha), net returns (Rs. 25267/ha) and B: C ratio (2.67) was observed in without nutrient application. From the experimental results, it was concluded that application of nutrient based on SSNM produced maximum seed cotton yield and monetary benefits under irrigated ecosystem in Tungabhadra command area.

2.5
Productivity and water use efficiency of transgenic cotton under different planting methods

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A field experiment was carried out at agronomy research area of CCS Haryana Agricultural University, Hisar, Haryana (29°10'N latitude, 75 °46'E longitude and 215.2 M altitude) during *kharif* season of 2012 and 2013 with split plot design having two methods of sowing (conventional and FIRBS) and two genotypes (*Bt* and non *Bt* cotton) in main plots and four levels of fertilizer (75per cent RDF,100per cent RDF, 125per cent RDF and 150per cent RDF) in sub plots with three replications to evaluate the productivity and water use efficiency of cotton under different planting methods. On the basis of two year study it was concluded that total water use was less in FIRBS planted cotton (60.2 and 62 cm) as compared to conventional planted cotton (63.4 and 64.3 cm), respectively during 2012 and 2013. WUE under FIRBS planting was higher by 16.2 and 15.0 per cent (33.7 and 30.6 kg/ha -cm) than conventional sowing (29 and 26.6 kg/ha -cm), respectively in 2012 and 2013. Boll weight and their numbers were significantly higher under FIRBS than conventional planted cotton during both the years of study. Boll weight and boll numbers significantly increased with the increase in level of fertilizers up to 125per cent RDF. FIRBS planting of cotton increased the seed cotton yield by 9.3 and 10.0per cent over conventional planting, respectively during 2012 and 2013. Seed cotton yield was significantly higher with 100per cent RDF as compare to 75per cent RDF during both crop seasons. Three levels of fertilizers (100%, 125% and 150% RDF) were *at par* in seed cotton yield during 2013 crop season. 150per cent RDF level yielded significantly higher seed cotton yield as compare to 100per cent RDF during 2012 crop season.

2.6
Cotton cultivars under salinity

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Seven cultivars of cotton *viz.,* H 1098 i, HD 123, RCH 134*Bt*, KDCHH 9810BG II, SOLAR 72BG II, GRAND BG II and NCS 856BG II were sown in micro plots at four different salinity levels in CCS HAU, Hisar. Salinity was given with irrigation water. Reduction in yield was observed with increasing salinity levels. About 30per cent reduction was observed with 5.0 dS/m salinity which further increased to 47 per cent with 7.5 dS/m salinity. RCH 134*Bt* performed better in terms of yield followed by KDCHH 9810BG II whereas HD 123 gave the poorest performance. No significant effect on fresh weight of plants was observed with salinity levels at the time of harvesting. Single boll weight decreased with increased level of salinity in all the cultivars but RCH134*Bt* showed relatively lesser reduction. Rate of transpiration also decreased with increased level of salinity in all the cultivars except KDCHH 9810BG II. Rates of assimilation consistently decreased with increased salinity levels in H 1098 i and GRAND BG II whereas RCH 134*Bt* and NCS 856*Bt* II showed opposite trend upto 5.0 dS/m. Decrease in stomatal conductance was also observed under saline conditions in most of the varieties studied indicating that this was the major factor affecting rates of assimilation or transpiration under saline conditions. Internal CO_2 concentration generally increased due to salinity except in HD 123 and NSC 856*Bt* II. During the study RCH 134*Bt* was found tolerant to salinity followed by KDCHH 9810BG II whereas HD 123 (*desi* cotton) found sensitive to salinity.

2.7
Foliar application of mepiquat chloride (PGR) under high density planting system on different species of cotton

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An field investigation was carried out at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *kharif* 2014-2015. The experiment was laid out in factorial randomized block design with three replications. *Arboreum* variety AKA 7 and *Hirsutum* variety AKH 081 were tested with 1.66 lakh plants/ ha (60 x 10 cm) on broad bed furrow system for better conservation of moisture and mepiquat chloride was sprayed at square and boll development stage and both stages under high density planting system. The cotton crop was sown on July 18th 2014, rainfall of the season was 512.1 mm. Monsoon was delayed by one month and withdrawal early. Spraying of mepiquat chloride @ 25 g a.i/ha at square and boll

development stage than other treatments reduced significantly plant height, leaf area index and dry matter Whereas, increased root length and total chlorophyll content in leaves after spraying of MC. The picked boll/plant and seed cotton weight/plant was recorded significantly higher in AKA 7 but maximum boll weight recorded with variety AKH 081. Seed cotton yield and biological yield kg/ha were significantly higher in AKA 7 over AKH 081. Foliar spray of mepiquat chloride @ 25 g a.i/ha square and boll development stage recorded significantly higher number of picked bolls/plant, boll weight and seed cotton weight/plant and SCY (1880 kg/ha) than alone spray of MC square development stage, boll development stage and control. However, biological yield was reduced due to MC spray. HDPS cotton sown on BBF with spraying of MC contributed the higher yield of cotton under delayed monsoon condition.

2.8

Cotton seed biofertification with plant growth promoting bacteria and *Trichoderma harzianum*

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Application of plant growth promoting bacteria plays an important role in crops yield and quality enhancement. The present study was conducted to assess the effect of azatobacter, Phosphate Solubilizing Bacteria , *Pseudomonas fluorescens* and *Trichoderma harzianum* on seed germination and seedling vigour of cotton hybrid Jadoo BGII and NDLH 1938. The study was conducted in green house with 13 treatments as seed inoculations were applied as single inoculation by each isolate and co inoculated in combinations and soaking with water and without inoculation as control treatments. Final germination per cent, shoot length, root length, root and shoot dry weight and seedling vigour index were recorded for all the treatments. The results of the study revealed that all treatments resulted in enhancement of seed germinability and seedling vigour parameters.Maximum germination per cent (90per cent), root length (22.75 cm), shoot length (15.36 cm), dry weight (0.67 g) and seedling vigour index was recorded in *P.fluorescens+T.harzianum* treatment followed by *P.fluorescens* and *T.harzianum* treatments alone and showed the synergistic effect of treatments which will help for healthy initial vegetative growth there by improvement in yield attributes and yield. The results suggest that specific combination of PGPR can be considered as efficient alternative biofertilizers to promote seed germination, biomass and crop yield in sustainable agriculture.

2.9
Response of *Bt* cotton to crop geometry and weed management practices

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A field experiment was conducted at Agricultural Research Station, Kadapa for two consecutive years during *kharif* 2012-2013 and 2013-2014 to find out the effect of crop geometry and weed management practice on the growth and yield of *Bt* cotton. Spacings did not exert any significance influence on kapas yield of *Bt* cotton. Among weed management practices, hand weeding thrice at 20, 40 and 60 DAS registered significantly highest *kapas* yield (1692 kg/ha) which was however *on par* with pre emergence application of pendimethalin @ 1.0 kg/ha followed by one hand weeding at 40 DAS (1653 kg/ha) as compared to other treatments.

2.10
Agronomic manipulation of high strength cotton genotype, CCH4474 for yield maximization under irrigated agro ecosystem of Coimbatore

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Field experiment was conducted during winter (August – February) cropping season of 2014-2015 at Coimbatore under irrigated condition to maximize the yield potential of high strength cotton genotype, CCH 4474. This genotype in spite of better fiber quality of high strength (> 24 g/tex) was rejected under multi location trial of AICRP due to poor yield of less than 13 q/ha . Field experiment was conducted with four geometry *viz.,* recommended (75 x45cm) : 29629 plants /ha , three high density plantings of (90x10 cm) **:** 1,11,111 plants/ha , (45x10 cm) : 2,22,222 plants/ha , (37.5x10cm) **:** 2,66,666 plants/ha under three fertilizer levels of 100 per cent RDF (60:30:30 NPK/ha), 125 per cent RDF and 150 per cent RDF. The design used was Factorial RBD with three replications. The soil of the experimental field was low in nitrogen (182.5 kg/ha), medium in phosphorus (13.75 kg/ha) and high in potassium (812.5 kg/ha). The EC of the soil was 0.24 (dSm^{-1}) with PH of 8.47. The boll/plant and boll weight were significantly altered due to geometry. The enhanced boll/plant at recommended spacing over closer spacings could not be compensated due to reduction in population which was drastically reduced on unit area basis. The boll weight was significantly higher at 90x10 cm and significantly reduced at higher population of 2,22,222 plants and 2,66,666 plants/ha . The recommended geometry of 75x45 cm recorded significant reduction in seed cotton yield over all the three geometries tried, and among them ,90x10cm to accommodate 1,11,111

plants/ha recorded the highest (3184 kg/ha) seed cotton and was *on par* with 45x10cm and 37.5x10cm. Among the fertilizer levels, 125 per cent RDF recorded the highest (3220 kgs/ha) and was *on par* with 150per cent RDF but found significantly superior to 100 per centRDF. Among the combination of treatments, the highest seed cotton yield of 3325 kgs/ha was recorded at 90x10cm with 125 per cent RDF. The interaction between geometry and fertilizer levels was not significant. The yield potential of high strength cotton genotype, CCH4474 was enhanced from 13 q/ha under breeders trial to 33.25 q/ha by agronomic manipulation.

2.11

Evaluating efficacy of foliar application of plant regulator on yield and growth attributes of *Bt* cotton (*Gossypium hirsutum* L.) in south western Punjab

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Cotton is a major commercial fibre crop of *kharif* of Punjab. Cotton as a crop as well as a commodity plays an important role in the agrarian and industrial activities of the nation and has a unique place in the economy of our country. The cultivation of *Bt* cotton is confined to owing to its benefits in south western region of Punjab. A field experiment was conducted at Regional Station, Punjab Agricultural University, Bathinda for two years during 2013-2014 and 2014-2015. The experiment was laid out in randomized block design on *Bt* cotton hybrid NCS 855 BG II of four treatments of plant regulator namely CASH PLUS as foliar application *viz.,* foliar spray of cash plus @ 2.0 ml/l water, 2.5 ml/l water, 3.0ml/l water and control with four replications. The foliar application of CASH PLUS was done at different stages of the crop *i.e.* 1^{st} spray at square formation, 2^{nd} spray at early bloom stage and 3^{rd} spray after 15 days of 2^{nd} application. Recommended dose of N (150 kg N/ha) was applied in the form of urea in two equal splits, ½ N at first irrigation and ½ N at flowering stage. The soil of the experimental site was loamy sand with pH 8.5, low in OC (0.38 per cent), medium in P and high in K. The recommended agronomic and plant protection measures were adopted to raise the crop. The data were recorded on plant height (cm), monopods/plant, sympods/plant, bolls/plants, boll weight (g) and seed cotton yield (kg/ha) which were analyzed statistically as per the standard procedure.

The mean values of two years research data revealed that application of foliar application of CASH PLUS at variable rates at three different growth stages of cotton in the treatments did not influence the growth characteristic of cotton and seed cotton yield. All the characters except plant height were statistically *at par* among themselves and were in comparison with control. This implies that foliar application of CASH PLUS as a plant regulator in cotton has exerted no significant effect on growth and yield of *Bt* cotton.

2.12
Integrated nitrogen management in *Bt* cotton (*Gossypium hirsutum* L.)

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A field experiment was conducted to study the integrated nitrogen management in *Bt*. Cotton (*Gossypium hirsutum* L.) on sandy loam soil at Agronomy Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar during *kharif,* 2013-2014. The experiment was laid out in randomized block design (RBD) with three replications. There were twelve treatments of integrated nitrogen management practices *viz.,*, T_1: 100per cent RDN (240 kg N/ha) through inorganic fertilizer, T_2: 125per cent RDN through inorganic fertilizer, T_3: 100per cent RDN through inorganic fertilizer + 25 kg $MgSO_4$/ha , T_4: 25per cent RDN through inorganic fertilizer + 75per cent RDN through castor cake, T_5: 50per cent RDN through inorganic fertilizer + 50per cent RDN through castor cake, T_6: 75per cent RDN through inorganic fertilizer + 25per cent RDN through castor cake, T_7: 25per cent RDN through inorganic fertilizer + 75per cent RDN through castor cake + *Azotobacter,* T_8: 50per cent RDN through inorganic fertilizer+ 50per cent RDN through castor cake + *Azotobacter,* T_9: 75per cent RDN through inorganic fertilizer + 25per cent RDN through castor cake + *Azotobacter,* T_{10}: 75per cent RDN through inorganic fertilizer + 25per cent RDN through castor cake + *Azotobacter* + PSB, T_{11}: 75per cent RDN through inorganic fertilizer + 25per cent RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha and T_{12}: 100per cent RDN through inorganic fertilizer + 25per cent RDN through castor cake + *Azotobacter* + PSB (T_{12}). Application of 100per cent recommended dose of N through inorganic fertilizer + 25per cent RDN through castor cake along with seed inoculation with *Azotobacter* and PSB recorded taller plants at 30, 60, 90 and 120 DAS, higher number of monopodial branches/plant at 60 and 90 DAS and sympodial branches per plant at 60, 90 and 120 DAS, number of balls/plant at 120, 150, 180 and at last picking, weight of seeds per boll, seed index, weight of seed cotton per boll, seed cotton yield, stalk yield, oil yield and total nitrogen uptake by stalk and cotton seed. However, different integrated nitrogen management practices did not reach to the level of significance with respect to number of seeds/boll, oil content of cotton seed, lint index, ginning percentage and mean fibre length. It also gave maximum net returns and BCR.

2.13
Effect of micro irrigation on yield and water production efficiency of cotton (*Gossypium hirsutum* L.) in saline vertisols of Tungabhadra project command area under conservation agricultural practices

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On farm experiment was conducted in saline (6-8 d/Sm) Vertisols during 2011-2012 to 2013-2014 for evaluating the response of cotton (*Gossypium hirsutum L.*) to applied irrigation water (IW, 0.8, 1.0 and 1.2 ET) with drip and furrow irrigation method under zero till mulch (paddy straw @ 6.85 t /ha) and no mulch treatments. The pooled data of three years revealed that the soil moisture content was significantly more in mulch with 1.2 evapotranspiration (ET) and least in no mulch with furrow irrigation in all the three growth stages of the crop and at all the four depths of soil (0-15, 15-30, 30-45 and 45-60 cm). Significantly higher seed cotton yield was obtained in case of drip irrigated at 1.2 ET (27.16 q /ha) which was *on par* with drip irrigated at 1.0 ET (26.16 q /ha) and least in case of furrow irrigation (21.05 q /ha). Among mulch treatments, significantly higher yield was obtained in case of mulch treatment (26.49 q /ha) compared to no mulch treatment (23.01 q /ha). Net saving in irrigation water through drip irrigation was 44, 29.4 and 16.8 per cent at the irrigation levels of 0.8, 1.0 and 1.2 ET, respectively as compared to the irrigation through furrow method. In ET treatments, water production efficiency (WPE) was significantly higher in drip irrigated with 0.8 ET (0.78 kg/m) and least in flood irrigated treatment (0.38 kg/m) and among mulch treatments, significantly higher WPE was obtained in mulch treatment (0.65 kg/m) compared to no mulch treatments (0.56 kg/m). Among irrigation levels, net seasonal income and B:C ratio were significantly higher with drip irrigation at 1.2 ET (Rs. 33,245 and 1.67) as compared to other irrigation levels. Among mulch and without mulch treatments, significantly higher net seasonal income and B:C ratio (Rs. 29,459 and 1.59) were recorded in mulch treatment. The payback period was lesser in case drip irrigation at 1.2 ET with mulch treatment (3.15 years).

2.14
In situ evaluation of underground poor quality water purifier cum descaler for irrigation to cotton on light textured soil in south western Punjab

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The dependence on the use of underground saline and/or sodic water seems inevitable due to ever shrinking good quality canal irrigation water supplies. Cotton is a major cash crop of *kharif* season in Punjab. In semi arid zone comprising south-western districts of Punjab, the major constraint is the acute

shortage of canal water and good quality underground water for surface irrigation. The farmers in the region sometimes fail to sustain cotton productivity because the soil may start getting degraded as a result of indiscriminate use of poor quality waters. Keeping in view the feedback by the farmers and realizing the importance of cotton crop in this zone, the present study was initiated in year 2009 on loamy sand soil with an aim to test the performance of water purifier to change the underground poor quality water to reasonably good quality water for irrigation to *Bt* cotton crop in cotton-wheat/*raya* cropping sequence. The experiment comprised of four treatments *viz.,* canal water (CW), raw tube well water (TW), purified Tube well water (PTW) and alternate TW/PTW irrigations with four replications in randomized block design. The residual sodium carbonate (RSC) and electrical conductivity (EC) of the raw tubewell water and canal water used was 6.4 and 0.5 meq/L; and 2200 and 450 µmhos/cm, respectively. In water purifier treatment, the brackish water is passed through a pipe fitted with poor quality tubewell water delivery pipe. The water quality parameters after passing the water through water purifier and raw poor quality tubewell water were tested simultaneously which showed no variation in the EC and RSC values between the two waters. Four to five irrigations of 7.5 cm depth each were applied to the crop. Although experiment was started in 2010 yet the research data of only one *kharif* 2014 has been presented. Results revealed that irrigation with TW, PTW and TW/PTW alternately produced statistically *at par* seed cotton yield which was significantly lower than canal water alone. The other yield attributing parameters *viz.,* plant height, sympods and bolls/ plant in CW treatment were also found to be significant than other treatments. The effect of TW and PTW treatments on soil characteristics was also found to be similar. It is concluded that water purifier cum descaler used in this experiment has no influence to effect changes in chemical composition of poor quality water.

2.15

Evaluation of *Bt* cotton (BG II) under different plant densities and fertilizer levels in conjuction with growth regulator under irrgation

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Cotton plays an important role in Indian farming and industrial economy of the country. The *Bt* Cotton is mainly cultivated under irrigation in Raichur,Bellary and Kalaburgi districts of Karnataka which cover part of Tungabhadra and Upper Krishna project areas.Among yield sustaining factors, optimum plant density is one which determines the final out put. With the interest in higher production through higher population, the concomitant problem is availability of cultivars suited for such condition. All the *Bt* Cotton cultivars are not suitable for high population cultivation. Many which are having Semi determinate to in determinate growth habit tend to put an excessive vegetative growth to induce dense canopies under given management practices. Agronomically these cultivars are not suited for narrow and high population cultivation unless their growth and canopy characters are modified. Excessive vegetative growth through dense canopy in *Bt* Cotton controlled by topping or by nipping mechanically or manually has been found to be costly and time consuming for adoption for large scale. Plant growth regulators serve as highly influential agents by which growth is regulated both in time and space at any point of time. The desire to manipulate plant growth while maximizing yield through high plant population has lead to interest in growth regulators. The present investigation was carried out for two years (2010-2011 and 2011-2012) under irrigation at Main Agricultural Research Station, Raichur to evaluate *Bt* Cotton (semi determinant, open erect, Bollgard II) to levels of plant population and fertilizers in conjunction with growth regulator application.The main plot treatments were three population levels (37037 plants /ha with 90x30 cm spacing, 24691 plants /ha with 90x45 cm spacing and 18518 plants /ha with 90x60 cm spacing control) while three fertilizer levels (100 per cent, 20125 per cent and 150 per cent RDF) and three growth retardant sprays (Control water spray, One spray of lihocin @ 0.2 ml/lit at 55 60 DAS and Two sprays of lihocin @ 0.2 ml/lit at 55 60 and 90 100 DAS) were assigned to sub plots. Brahma cultivar which has semi determinate growth habit was used for the study.RDF consisted of 150:75:75 kg NPK /ha. The pooled data of MARS, Raichur over two seasons (2010-2011 and 2011-2012) indicated that higher plant population of 37,037 plants /ha with 90×30 cm spacing resulted in significantly higher seed cotton yield (2933 kg/ ha) over plant population of 18,518 plants /ha with 90×30 cm spacing (2330 kg/ha) but found *on par* with that of 90×45 cm plant spacing with 24,691 plants /ha (2619 kg/ha) . Among fertilizer levels and growth regulator sprays, higher seed cotton yield of 2791 kg/ha was noticed with 150per cent RDF + lihocin spray at 55 60 DAS which was significantly superior over all other treatments except 150per cent RDF + lihocin sprays taken up twice at 55 60 DAS and 90 100 DAS, 125per cent RDF + lihocin sprays at 55 60 DAS and 150per cent RDF alone treatments. Interaction effects were not found significant. Economic analysis indicated that though higher plant population of 37,037 plants/ha recorded significantly higher net returns but found *on par* with the population of 24,691 plants/ha with 90 x 45 cm spacing. Similarly application of 150 per cent RDF with along with lihocin spray at 55-60 DAS though fetched higher net returns over other treatments except the treatment of 125 per cent RDF + lihocin spray at 55-60 DAS . B:C ratio also followed the similar trend. In semi indeterminate *Bt* cotton hybrids , higher yields and net returns can be obtained by adopting higher plant population of 24,691 plants /ha at 90×45 cm spacing with 125per cent RDF and foliar spray of 0.2 ml/lit of lihocin (growth retardant) when the crop is at 55-60 days old (when plants attain the minimum height of 60 to 75 cm).

2.16

Performance of compact genotypes of cotton under high density planting in Tamil Nadu

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Cotton is cultivated in an area of 1.39 lakh ha in Tamil Nadu with a production of 2.80 lakh bales and a productivity of 611 kg/ha (AICCIP Annual Report, 2014 -2015). As regards productivity, the north zone ranks first with 730 kg/ha. Lint yield in cotton is determined by boll density (bolls/unit area), individual boll weight and the percentage of fibre/boll. Coupled with pest management, ever growing labour shortage for picking escalates the cost of production in cotton. This necessitates mechanical harvesting which requires higher plant densities at 6.5 – 9.0 plants m^{-2} in combination with more compact plant type. Plant density can be used to manipulate these yield components. There is a scope for increasing the productivity in Tamil Nadu with the compact and erect genotypes of cotton with synchronized and early boll maturity suitable for mechanical harvest that have been developed at TNAU. These genotypes are being tested under high density planting systems. Two such genotypes *viz.*, TCH 1705 and TCH 1819 were tested under high density planting systems, (*i.e.,)* 1.48 lakh plants/ ha (45 x 15 cm), 1.10 lakh plants/ ha (60 x 15 cm) and 0.44 lakh plants/ ha (75 x 30 cm) under factorial randomized block design with four replications during summer, 2015. The recommended fertilizer dose of 80:40:40 kg NPK/ ha was applied. The results revealed that the seed cotton yield of TCH 1819 was significantly higher (2428 kg/ha) than TCH 1705 (2198 kg/ha). Among the plant densities, 1.10 lakh plants/ha (60 x 15cm) registered significantly higher yield (2294 kg/ha) followed by 1.44 lakh plants / ha (45 x 15 cm) (2006 kg/ha) and 0.44 lakh plants/ha (1541 kg/ha).

2.17

Soil health enhancement with the use of bio products- Key to the improved yields in rainfed cotton based cropping system

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Spreading good practices for improvement of soil health on wide scale has always been a challenge. At the same time, the productivity of rain-fed cotton and red gram grown in the dry land farms is very low compared to irrigated areas. Hence use of organic components (bio culture) in agriculture becomes significant step forward for rainfed crops grown in Karnataka. The organic amendments in soil are reported to improve soil organic matter and supress plant diseases etc.

The farmers are usually reluctant to use organic components (bio products) in soil/ for crops, due to its slow mode of action in releasing of nutrients to aid short term increase. Keeping these views, a joint initiative for organic cultivation with low inputs, the trials on cotton and red gram were taken with farmers adopted by youth for action, Hyderabad based NGO working for disadvantaged communities for last 25 years. The bio/organic products were provided by Pune based manufacturer, Ajay Bio-Tech (I) Ltd.

Study was conducted in 10 farmer’s field for cotton and red gram crops, which are grown on dry land area of Itkal and Kakarwal villages, Gurumitkal block, Karnataka. Three treatments viz. 1. farmer’s practice (1 ton FYM once in two years, 60:30::N:P) 2. Progressive farmers practice (2 tons FYM once in two years, 90:30:: N:P for cotton) and 3. Use of bio products (2 tons FYM + 15 kg/ha Ajay Meal+ 3-4 sprays of Grow-Rich) consisted for conducting the trials.

Observations recorded on the plant growth parameters indicate that the plant height and number of fruiting branches/balls found to be increased in the range of 20-30 per cent with the use of bio-products like Ajay Meal and Grorich Plus as compared to farmer’s practice and15-20 per cent as compared to progressive farmer’s practices. Regarding soil health, organic carbon and releasing of soil nutrients are found to be improved with the use of bio products.

2.18
Effect of foliar spray of potassium nitrate on yield of cotton

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The present investigation was carried out at 43 locations in 29 villages of Hisar district during *kharif*, 2010 season to study the effect of foliar spray of potassium nitrate (KNO_3) on yield of cotton. The two treatments comprised of recommended dose of fertilizers (T1) and the foliar spray of KNO_3(2%) along with recommended dose of fertilizers (T2). The soils of the experimental sites were low in available nitrogen, medium in available phosphorus, rich in available potash and slightly alkaline in reaction having pH range of 7.6 - 8.2. The *Bt* cotton hybrid Rasi 134 was sown during the month of May at all the sites. The recommended dose of fertilizers used were; 175 kg N, 60 kg P_2O_5, 60 kg K_2O and 25 kg $ZnSO_4$ /ha. Nitrogen, phosphorus, potash were applied as urea, single super phosphate and murate of potash, respectively. The 1/3rd of nitrogen and full dose of phosphorus, potash and zinc sulphate were applied as basal dose at the time of sowing. Four sprays of KNO_3 with composition of NPK (13-0-45) @ 5kg/ha were done, starting from flower initiation and subsequent sprays at an interval of 10 days. All the other recommended package of practices were adopted during crop growth period.

The results obtained from all the locations were analyzed and pooled to draw the conclusion. The results revealed that an average yield of 21.1 q/ha was obtained with the application of KNO_3 as foliar spray in comparison to the treatment having recommended dose of fertilizers only (19.3 q/ha). The KNO_3 spray enhances the seed cotton yield to the tune of 9.3 per cent over control treatment (T1).Among the locations, the highest seed cotton yield obtained was 27.0 q/ha for KNO_3 spray whereas the corresponding value for the control was 24.0 q/ha.

2.19
Optimum times of sowing and identification of yield influencing weather indices

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Cotton is the most important fibre cum cash crop of our country, sustaining one of the country’s largest organized industry and our productivity is 537 kg/ha.Optimum time of sowing provide favorable weather condition to crop growth ultimately lead to higher yield. Keeping this view, the experiment was undertaken to find out optimum time of sowing, identification of yield influencing weather parameters/indices and fitting of model . A field trial was conducted under irrigated condition at New Area farm of Central Institute for Cotton Research, Regional station, Coimbatore, Tamil Nadu during the fall season (August to February) of 2014-15. The treatments comprised of nine different dates of sowing (D1.21st July,D2.28thJuly,D3.4thAugust,D4.11t August,D5.18th August,D6.25th August,D7.1st Sep.D8.8th Sep.D9.15th Sep.) with two genotypes (Mallika BGII, and Suraj) .Seed cotton yield was not influenced significantly by genotypes and interaction effect of genotypes with date of sowing. However, significant influence was observed with date of sowing; 4th August sowing(30.9q/ha) registered significantly highest seed cotton yield which was on par with 21st July (26.8q/ha), 28th July(28.0q/ha), 11th August(27.7q/ha),18th August(26.4q/ha)and 25th August (24.3q/ha) . The result indicate sowing window of 21st July to 25th August. Different times of planting (nine) of Mallika Bt BG II and Suraj had not influenced the quality parameters. Genotypes (Mallika Bt BG II and Suraj) did not vary significantly by quality parameters except higher uniformity ratio with Mallika Bt BG II. Significantly highest nutrient uptake and less available nutrient status of soil were found with optimum times of sowing (4th August).The significant positive correlation was noticed with 31-60 and 61-90DAS of GDD, Etc , mean temperature and Sunshine hours with seed cotton yield. The positive correlation was also observed with 131-160DAS of GDD and rainfall with seed cotton yield. Yield influencing parameters includes rainfall, temperature, solar radiation at germination, vegetative growth and reproductive phase, incidence of sucking pest and bollworms, times of sowing (early, normal and late onset of monsoon) and soil depth and environment (irrigated or rainfed) were scored from 0 to 10 based on degree of influence at different growth periods . The highest score was awarded to optimum points and reduced scores were awarded for both for higher and lower sides. Score of yield influencing factors were scored for different dates of sowing. The estimated scores were correlated with yield data obtained at different dates of sowing and subsequently equation was developed for yield prediction by using shifted power model. $Y= a (x-b)^c$ ($r=0.96$, $r^2 = 0.91$) (a=19.611, b=0.73,c=0.320).The chi square test was employed to compare actual and predicted yield found that non significant differences between the two types of yield. The differences of yield prediction ranged from 7.4 -9.8 per cent

2.20

Heat use, helio thermal use and radiation use efficiency of *Bt* cotton as influenced by sowing windows under rainfed conditions of Andhra Pradesh

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A field experiment was carried out during *kharif,* 2010-2011 and 2011-2012 on clay soils of Regional Agricultural Research Station, Lam, Guntur. The experiment consists of six dates of sowing windows *viz.,* 2 FN of July, 1 FN of Aug, 2FN of Aug, 1 FN of Sept, 2 FN of Sept and 1 FN of Oct to know the heat use efficiency, heliothermal use efficiency and radiation use efficiency of *Bt* cotton (NCS 145) in Krishna agro climatic zone of Andhra Pradesh. The results indicated that the *Bt* cotton sown on 2nd FN of July has received maximum heat use efficiency, heliothermal use efficiency and radiation use efficiency (131.55 MJm^{-2}) and consequently resulted in to maximum seed cotton yield (2510 kg/ha^{-1}) followed by crop sown on 1st FN of August with a yield of 1820 kg/ha^{-1}. Statically significant correlation was found between radiation use efficiency and seed cotton yield of *Bt* cotton under rainfed conditions of Andhra Pradesh.

2.21
Performance of *Bt* cotton under closer spacing

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Cotton is one of the major commercial crops in Krishna district of Andhra Pradesh. During the *kharif* season, 2012-2013; an area of 67585 ha was covered with *Bt* cotton. As the majority of farmers in the district follow conventional wider spacing, the yield potential of cotton hybrids is not realized to the maximum; particularly in light soils as the vegetative growth of cotton plants is also poor. Keeping this in view, on farm trials were conducted in three locations to find out the performance of *Bt* cotton under closer spacing of 90 cm x 60 cm during 2012-2013. With adoption of closer planting, an average yield of 2650 kg/ha was obtained with a net income of Rs. 1,00,700/- and net return of Rs. 55,700/- compared to the farmers practice where only 2120 kg/ha was realized that fetched a net income of Rs. 80,560/- and net return of Rs. 35,560/-. The benefit cost ratios were 1.24 and 0.8 for closer spacing and wider spacing respectively. Further, it was also observed that in black soils of Jaggaiahpet region where closer spacing was adopted, the plants were grown to a height of 6-7 feet due to frequent rains received during the season. The total rainfall received from June, 2012 to March, 2013 was 1544 mm from 62 days against the normal rain fall of 1034.0 mm, due to which spraying for the control of sucking pest complex became difficult. As higher relative humidity was maintained under the canopy, the crop was also affected by grey mildew disease. Thus, in some fields the cost of plant protection was increased greatly. Hence, adoption of closer spacing in lighter soils may be useful in getting increased yields, but in heavier fertile soils much attention is also required on fertilizer doses and irrigation schedules with special focus on plant protection.

2.22

Decadal change in the profitability of cotton grower in Haryana state

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Cotton is known as "White Gold" in India. It is important commercial crop cultivated in India. It plays a major role in sustaining the livelihood of an estimated 5.8 million cotton farmers and 40-50 million people engaged in related activity such as cotton processing and trade. The textile industry contributes significantly to the economy in terms of industrial output, employment generation and the export earnings of the country. It contributes about 4 percent to GDP, 14 per cent to the industrial production and 17 per cent to the country's export earnings. The Indian textile industry provides direct employment to over 35 million people as it is the second largest provider of employment after agriculture. India is one of the few countries in the world to have a well established, complete value chain in the textile industry. Of the total, approximately 62 percent of Indian cotton is grown under rainfed and 38 per cent on irrigated area. The acreage under cotton was 11.73 million hectares in India whereas in Haryana state 0.56 million hectare during the *kharif* 2013-2014. Although area and production of cotton has increased in state after instigation of *Bt* cotton but the increment in profitability from the cotton cultivation has not witnessed in the same ratio at which cost of production has increased from Rs. 1638 to Rs. 4800/q during the year 2004 to 2014 *i. e.* nearly 194 per cent. Whereas returns over variable cost showed an increase from Rs. 15205 to 26953/ha which was only 77 per cent increment during the same period. At the same time increment in minimum support price were observed only 107 per cent, *i.e.* from Rs. 1960 to Rs. 4050/q from the year 2004 to 2014. Therefore, immense need of appropriate price policy interventions that would be helpful to increase the profitability of the cotton growers in the state.

2.23

Management of leaf reddening in *Bt* cotton

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A field experiment was carried out for 3 years during *Kharif* 2009-2010, 2010-2011 and 2011-2012 to study the response of *Bt* cotton to recommended dose of fertilizers based on soil test values and foliar sprays of different nutrients under irrigated conditions in black soils at Agricultural Research Station, Siruguppa. The Experiment was laid out in randomized block design with 3 replications. The experiment consists of 10 treatments, *viz.,* T_1 : control (recommended dose of fertilizers), T_2 : RDF based on soil test values, T_3 : T_2 +

FYM @ 10 tons /ha, T_4 : T_3 + FYM@ 10 tons /ha + 2 foliar sprays of 2 per cent urea @ flowering and boll development stage, T_5 : T_3 + 2 foliar sprays of DAP @ peak flowering and boll development, T_6 : T_3 + 2 foliar sprays of 2 per cent19:19:19 @ peak flowering to boll development stage, T_7 : T_3 + 2 foliar sprays of 2 per cent urea + 2 foliar sprays of 2 per cent DAP (alternatively) starting from flowering to boll development stage, T_8 : T_3 + 2 foliar sprays of KNO_3 (2%) + DAP (2%) during flowering to boll development stage, T_9 : T_3 + 2 foliar sprays of 2 percent KNO_3 + 1 spray of 1 per cent $MgSo_4$ during flowering to boll development stage, T_{10} : T_3 + 2 foliar sprays of 2 per cent urea @ peak flowering and boll development stage + 0.5 per cent of $ZnSo_4$ during flowering to boll development stage. The cotton hybrid Bunny Bt (NCS-145) BG II was dibbed with 90 x 60 cm spacing. The recommended dose of fertilizers (120 : 60 : 60 kg NPK/ha) was applied to control plot. The fertilizer dose of 150 : 75 : 75 kg NPK/ha (based on soil test values *i.e.* 25 per cent extra to the recommended dose) was applied to rest of the treatments and all other recommended practices were followed. Results based on the 3 years pooled data revealed that RDF based on soil test values + FYM 10t/ha + 2 foliar sprays of 2 per cent KNO_3 + 2 per cent DAP during flowering to boll development stage recorded significantly higher seed cotton yield (2311 kg/ha), net returns (Rs. 54509/ha) and B:C ratio (2.28) as composed to control (Rs. 33488/ha). Treatment T_8 recorded lower score and grade regarding leaf reddening during 90 DAS and 120 DAS during all the three years.

2.24

Response of *desi* cotton genotypes to high density planting system and different nutrient levels

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A field experiment entitled, " Response of *desi* cotton genotypes to high density planting system and different nutrient levels" was conducted at Cotton Research Station ,M.B. Farm, VNMKV,Parbhani during *Kharif*, 2014-2015 on clayey soil, alkaline in nature with low available nitrogen ,medium phosphorus, rich in potassium. The climatic condition during experimental period was favourable. The experiment was laid out in split plot design with three levels of fertilizer(nutrient) dose , three high density plant system and three *arboeum* cotton(*desi*) variety with three replication. *Arboreum* cotton(deshi) varietywas sown on 14th July, 2014 by dibbling two seeds/hill as per given density planting system.

The growth and yield parameters were improved with. Differences in seed cotton yield due to plant densities were evident.Among the different densities the plant density (S_2-148,148 plant/ha, 45 x15 cm) recorded significantly superior higher seed cotton yield (1406 kg /ha) over rest of plant density.Fertilizer levels singnificantly affected the seed cotton yield/ha. Increase in fertilizer levels resulted to increase in seed cotton yield/ha. Among different fertilzer levels, 150 per cent RDF (75:37.5:37.5 NPK kg/ha) was found significantly superior higher seed cotton yield (1412 kg/ ha) over rest of fertilizer levels**.** Fertilizer level 100 per cent RDF (50;25:25 NPK kg/ha) recorded lowest seed cotton yield but was found *at par* with the fertilizer level 125 per cent RDF(62.5:31.5:31.5 NPK kg/ha). In case of the different *arboreum* cotton varieties V_2- PA 528 recorded **s**ignificanty higher seed cotton yield (1412 kg /ha) and was found *at par* with V_1- PA- 08(1319 kg /ha).

From the present investigation it can be inferred that an application of 150 per cent RDF (75:37.5:37.5 NPK kg/ha) in high density planting system S_2-148,148 pl /ha, 45 x15 cm and *arboreum* cotton varieties V_2- PA 528 observed to be beneficial in increasing growth and yield of *arboreum* cotton. Interaction effect were found non significant.

2.25

Optimization of nutrient requirement and plant geometry for different *Bt* cotton hybrids in canal command area of north-west Rajasthan

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A field experiment was conducted during *kharif* 2010-2012 at Agricultural Research Station, Sriganganagar. The treatment combination consisting three *Bt* hybrids in main plots (MRC 7017, GK 212 and RCH 314), two spacing in sub plots (67.5 x 90cm and 108 x 60cm) and two fertilizer levels in sub sub plots (100 per cent and 125 per cent RDF) with four replications. The results revealed that significantly higher seed cotton yield was recorded under MRC 7017 (2871 kg/ha) closely followed by GK 212 (2445 kg/ha) and lowest was recorded under RCH 314 (2243 kg/ha). The increase in yield under this hybrid might be due to significant increased bolls/plant and boll weight. Higher seed cotton yield was recorded under narrow spacing as compared to wider spacing. Increasing dose of fertilizer from 100 per cent RDF to 125 per cent RDF could not show its impact on seed cotton yield and application of 100 per cent RDF (150: 40: 20) seems to be optimum dose of fertilizer for both the years of experimentation. As regard nutrients uptake and nutrient use efficiency highest was recorded in hybrid MRC 7017 and lowest was recorded in RCH 314.

2.26

Physiological basis of heterosis studies in cotton under high density planting system (HDPS)

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Cotton accounts for 40% of the total global fibre production. India is a major player with world cotton market in terms of area and production. Drought and changing climate pattern decrement the crop yields. suitable genotypes and planting systems suitable for water deficit conditions are yet to be worked out. HDPS enables profitable cropping, high regular yields and improved farm management practices, leading to higher productivity. This system involves planting of plants densely, allowing small or dwarf plants with modified canopy for better light interception and distribution. Cotton yields in upland, rainfed regions can be increased by higher plant populations that optimize numbers of bolls per plant and boll weight, while lowering cost of cultivation.

This study was taken up with an aim to prove that narrow spacing are beneficial and result in high yields. In the present study six genotypes *viz.,* ADB-39, H-4492859, NDLH-1938, Anjali, Suraj and WGL-48 were taken and planted at 3 different spacings *i.e.,* 75 X 10, 60 X 10 and 45 X 10 cm in a replicated design. Observations were recorded at three stages of the crop growth period *i.e.,* square, flowering and boll formation stages.

The results shows that the performance of plants differed significantly under the three spacings and between the genotypes. Plants grown under 70 X 10 cm spacing as compared to 60 X 10 cm and 45 X 10 cm are good with respect to plant height and dry weight. Consequently, the plants recorded high Crop Growth Rate (CGR) and Relative Growth Rate (RGR), more accumulation of dry matter which may be attributed to utilization of available nutrients, sunlight and moisture. Dry matter is coupled with increased plant height, number of leaves and leaf area. Leaf Area Index (LAI), Leaf Area Duration (LAD) in spacing 70 X 10 cm is also high than the other two closer spacings. The superior yield performance in terms of yield and yield attributing characters are discussed.

2.27
Identification of suitable cotton genotypes for Alfisols of Southern Telangana Zone

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Cotton is a soft, fluffy staple fiber that grows in a boll. The fiber is almost pure cellulose. The plant is a shrub native to tropical and subtropical regions around the world, including the Americas, Africa, and India. The fiber is most often spun into yarn or thread and used to make a soft, breathable textile. Current estimates for world production are about 25 mt. India is ranked second with an area of 115.53 lakh ha and production of 375 lakh bales in 2013-2014. Telangana region covers 17,000 to 20,000 ha annually. Genotypes show varied growth expression and yield owing to the un predictable monsoon pattern and climate change effects. High Density Planting System (HDPS) a new concept enables high plant stand and improved productivity. Hence a field experiment was conducted at the College farm, Rajendranagar during *kharif* 2015-2016. Cotton genotypes were sown in to three plant spacings of 75 x 10 cm, 60 x 10 cm and 45 x 10 cm. Two varieties ADB 542 and Narasimha were compared with hybrid Deltapine-9121. Data was recorded at three crop growth stages namely square, flowering and boll development. Results indicated that sowing at 75 x 10 cm recorded significantly higher value for plant height in Deltapine (78.2

cm) followed by ADB 542 and Narasimha at boll developmental stage as compared to other two spacings *i.e.*, 60 x 10 cm (69 cm) and 45 x 10 cm (62.3 cm) Significantly high values were recorded in Deltapine over the two varieties for number of sympodial branches (17.33, 15.3, 14), leaf area (34.89, 16.6, 14.4 dm^2), total dry matter (119.16, 56.69, 49.2 g/plant), Crop Growth Rate (1.61, 0.76, 0.66 g/day) (CGR), relative growth rate (0.0023, 0.0010, 0.0009 g g/day) (RGR), net assimilation rate (0.0025, 0.001, 0.0009 g/dm^2/ day) (NAR), specific leaf weight (4.05 mg/cm^2) (SLW), leaf pigments (Chlorophyll-a (1.11 mg/g), Chlorophyll-b (1.77 mg/g), total chlorophyll (3.13 mg/g) and yield 30.32, 24.45, 23.17g/plant.

2.28
High production cost of *Bt* cotton : input based analysis from field survey

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Introduction of *Bt* cotton in 2005 in North India came as a boon to the cotton farmers. It reduced the number of sprays considerably, which were required for controlling boll-worms. Adoption of *Bt* on large scale, especially of undescriptive hybrids resulted in the emergence of newer problems associated with such *Bt* hybrids. This further resulted in high production cost of *Bt* cotton, which has forced farmers to shift the area under other crops. As per the field survey, about 16.26 per cent of the previous year cotton area in Fazilka district shifted to other crops. Among inputs, cost of seed is much higher, with farmers using more seed rate than recommended. About 58per cent of the farmers use 1800 g/ac of cotton seed, 35per cent of them use 2400 g/ac and 5per cent use still higher seed rate, which resulted in higher seed cost/ac. No farmer was found to follow recommended seed rate.Unbalanced use of fertilizers is another factor, with 94per cent of them applying more phosphorus, and 56per cent applying lesser nitrogen than recommended. Only 18.6 per cent of the farmers used one or the other herbicide for the control of weeds, while remaining all controlled the weeds manually. This has significant effect on the cost of production as manual weed control is expensive than chemical weed control. High number of pesticide sprays, with 33.7per cent of farmers applying more than 7 sprays, for the control of sucking pests result in more expenditure. In the last, the labour cost of picking of cotton is Rs.4-6/ kg, which is about 10-15per cent of the gross income from the cotton. This suggests lowering seed rate, applying recommended fertilizers, using chemical weed control, and managing pesticide use judiciously can help in lowering production cost significantly. Mechanical picking of cotton may be looked forward to replace the manual labour in near future.

2.29
Extension : A tool to enhance the knowledge of cotton growing farmers

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Cotton is the major *kharif* crop of western Haryana. It is the only cash crop grown in Hisar, Sirsa, Bhiwani and Jind districts of Haryana state covering about 52 per cent of total cultivated area. There is a huge gap between the recommended and adopted practices of cotton growing farmers and ultimately this leads to the low production of this particular crop. For the last 2-3 years, the yield of cotton crop is reduced up to 70 per cent by the attack of whitefly in this cotton growing pocket. The resistance has developed in white fly against different insecticides and pesticides. The reasons may be untimely sowing of cotton crop, indiscriminate use of pesticides and fertilizers etc. So, it becomes necessary for the extension agencies to aware the cotton growing farmers for different cultural practices of cotton production technologies *viz.,* time of sowing, emergence of pest, economic threshold level, combination of different insecticides and pesticides, spray techniques etc. The knowledge of cotton growing farmers can be enhanced about the attack and control of white fly by organizing different training programmes, campaigns, front line demonstrations, kisan gosthies etc. One of the most important and latest tool of transferring agricultural technologies is cyber extension. Modern communication technologies when applied to conditions in rural areas can help to improve communications, increase participation, disseminate information, share knowledge and skills. Cyber Extension can be defined as the "extension over cyber space". Cyber Extension means "using the power of online networks, computer communications and digital interactive multimedia to facilitate the dissemination of agricultural technology. The cotton growing farmers can learn and understand effectively and efficiently the production technologies of cotton crop by these latest communication tools.

2.30
Input impact analysis of cotton production in transition economy of Indian agriculture

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Over the past few years, India has achieved significant growth in cotton production. Evolution of cotton in India, over the last six decades after independence, shows that it has passed through five different phases which have been characterised by varying production practices evolving around technology in use, input requirements, and level of mechanisation, which were determined by emerging issues – but primarily the need for increasing production at that point of time. Relationship between the cost of production on one hand and the level of production and yield on the other has direct bearing on the sustainability of lives and livelihood of cotton farmers. The cotton production process involves use of various inputs for which the increased price of the same results in higher cost of production. The main objective of the study was to work out the trend of input growth affecting cotton production in India. The yield comparison with the three major cotton producing countries showed that there is a wide difference between those countries with India (China 60per cent, USA 40per cent and Pakistan 10 to 30per cent over years from 2005-2006 to 2015-2016). Regression analysis showed all the factors *viz.,*, seed, fertilizers, irrigation and plant protection had negative impact on the total income through increased yield excepting human labour which had negative impact in decreased total income. Correlation matrix indicates a high and positive correlation between the input variables. Input growth rate was highest in case of human labour (16.59per cent) and plant protection was the least (3.86per cent) showing the need for mechanized cotton farming and positive impact of *Bt* cotton in India. Analysis revealed that input cost have increased over time. Cotton pricing in India should be given a facelift to encourage cotton farmers to stay rather than shift to other competitive crops.

2.31

Impact of price forecasting on cotton farmers in Andhra Pradesh

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Market information and intelligence inputs are thus crucial for farmers who wish to become fully market orientated and ensure that their production programmes are tuned with changing market demand and conditions. The availability of predicted reliable market information can assist farmers in optimizing their resources to reduce the risks associated with marketing decide where to sell the produce check whether or not the prices they are offered are in line with market prices decide whether or not to store, decide whether to grow produce “out-of-season”; decide whether or not to grow different products; and could be helping in reducing risks. The Agricultural Market Intelligence Centre (AMIC) of S.V .Agricultural college, Tirupati has been releasing price forecasts during pre sowing and pre-harvesting period of mandatory crops of the state of Andhra Pradesh. The percentage of validation of price forecasts from 81 to 96 per cent. Impact of the farm advisory on forecasted prices of cotton during 2011-12 to 2013-14 was carried out in 5 mandals of Krishna zone in Andhra Pradesh given by the Agricultural Market Intelligence Center (AMIC) under Acharya N.G.Ranga Agricultural University. A sample of 50 farmers in the 5 mandals was randomly selected for the purpose of the study. 56.25 per cent of the farmers could able to know the price forecast through media released by AMIC. About 31.25 per cent depended on telephone enquiries from AMIC and farmers' training programmes conducted in the districts.. The Department of Agriculture and marketing was the source of information for 12.5 per cent of the farmers. The farmers realised Rs.20547/- as Additional revenue/ ha by adopting the forecasted prices in their selling decisions of cotton. The benefit cost ratio of adopted farmers was 0.32 when compared to non adopted farmers 0.11.

2.32
Site specific nutrient management in *Bt* cotton under Tungabhadra command area of Karnataka

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Cotton is the most important commercial fiber crop cultivated in diverse agro-climatic situations in India. *Bt* cotton is an exhaustive crop and needs more nutrients to attain a higher yield. Further, nutrient recommendation differs with crop response, genotypes, soil and climatic conditions. Site specific nutrient management (SSNM) which suggests need based supply of nutrients ensures application of nutrients at right time in desired quantities for the crop to obtain set target yields. Besides, omission of any nutrient in crop growth also shows its role in limiting the crop yield. Hence, a field investigation was carried out to study the site specific nutrient management in *Bt* cotton under irrigated ecosystem at Agricultural Research Station, Siruguppa, during *kharif* 2008-2009 on deep black soil with available nitrogen, P_2O_5 and K_2O of 195.7, 15.5 and 430.1 kg/ha, respectively. The experiment was laid out in a randomized block design with three replications. The experiment consisted of eleven treatments *viz.,* T_1: Absolute control (No fertilizers), T_2: Nutrients for 30 q/ha yield targeted (135: 75: 150 N-P_2O_5 and K_2O kg/ha plus macro and minor nutrients), T_3: T_2 minus N, T_4: T_2 minus P, T_5: T_2 minus K, T_6: T_2 minus Ca, T_7: T_2 minus Mg, T_8:T_2 minus S, T_9: T_2 minus Zn, T_{10}: T_2 minus Fe and T_{11}: T_2 minus B. The hybrid used in experiment was RCH 2 *Bt* BG II with spacing of 90 x 60 cm. The experimental results revealed that, application of nutrients for 30 q/ha targeted yield (135:75:150 N, P_2O_5 and K_2O kg/ha plus macro and minor nutrients) registered significantly superior seed cotton yield (2942 kg/ha) with higher gross, net returns and B:C ratio of Rs. 76501/ha , Rs. 54014/ha and 3.40, respectively as compared to without nutrient application (T_1), N omission (T_3), P omission(T_4) and K omission (T_5) treatments. Significantly lower seed cotton yield (1552 kg/ha), gross return (Rs.40361/ha), net returns (Rs. 25267/ha) and B: C ratio (2.67) was observed in without nutrient application. From the experimental results, it was concluded that application of nutrient based on SSNM produced maximum seed cotton yield and monetary benefits under irrigated ecosystem in Tungabhadra command area.

2.33

Site specific nutrient management for yield maximization and cost reduction for *Bt* cotton crop in Andhra Pradesh

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India has unique place among the cotton growing countries of the world. India ranks 5^{th} an area and third in production of cotton is 512 kg lint/ha . Among the cotton growing states, Andhra Pradesh is having an area of 7.36 lakh ha, second in production, 21.10 lakh bales and an average productivity of 621 kg lint /ha . *Bt*. cotton crop is an exhaustive crop and needs heavy fertilization to achieve higher yield as compared to *desi*, American cotton varieties and hybrids. It is known that nutrient removal is higher (25per cent extra) in *Bt* cotton hybrids. In general a rainfed cotton crop removes about 6-7 kg N, 2-2.5 kg P, 7-8 kg K/ 100 kg seed cotton. Nutrient recommendations varies with crop response, genotypes, soil and climate conditions

Site specific soil nutrient management (SSNM) is an approach to tailor fertilizer application to match field specific needs of crops to improve productivity and profitability. This could be done by utilizing available information on indigenous nutrient supplying capacity, nutrient contributions from organic manures, irrigation water, rainfall and crop residue pools and finally crop nutrient demand for targeted yield of crops/ cropping systems. With these considerations, the present investigation was undertaken to identify the best nutrient management strategy for various production systems for achieving maximum attainable yields and profits, and to see its effect on important soil fertility parameters, nutrient harvest index and apparent nutrient balance. A field experiment was conducted in B.K.Palem village of Guntur district with three treatments *viz*., T_1 : Farmer practice , T_2 : RDF of the Zone (150-60-60 NPK /ha) with each an area of 0.60 ha respectively and T_3: Site specific nutrient management (1.05 ha) during *kharif*, 2013-2014.

A total of 58 samples were collected on GRID basis along with GPS readings and analysed for pH, EC, Available N,P,K,S,Zn,Cu,Fe and Mn. Based on soil analysis data and STCR equation of cotton crop, fertilizers doses were calculated for each grid and applied in three splits *viz.,* basal, square formation stage and boll development stage. 150 soil samples were collected by using GPS covering entire village during *rabi* season 2013-2014. Soil analysis indicated that soils are alkali in reaction, non-saline, nitrogen, phosphorus and potassium in low, medium and high, respectively. The micro nutrients *viz.,*, Zn and Mn are difficient where as Cu and Fe are sufficient in fertility status. Grid wise yield was recorded and the highest cotton yield was recorded at farmers practice with a yield 27.5 q/ha followed by RDF practice. The cost of cultivation was high in farmers practice when compared to RDF and SSNM treatments. Low cost of cultivation and high net returns were recorded in SSNM plot with B: C ratio of 1.52 which was *on par* with RDF treatment.

2.34
Influence of post biomethionated treated spent wash on yield and physiochemical properties of soil after harvest of cotton

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A field experiment was conducted to study the effect of Post Biomethionated treated spent wash on physiochemical properties of soil at harvest of cotton and yield of cotton on *vertiso*l at the farm of department of Soil Science and Agricultural Chemistry, VNMKV, Parbhani during 2007-2008, 2008-2009 and 2009-2010. The experiment was laid down in RBD with eight treatments and replicated four times with variety *Bt* Rasi 2 of Cotton. The treatments were T_1: The recommended dose of fertilizer (80:40:40 NPK kg/ha), T_2: (100% spent wash alone), T_3: (75% Spent wash + 25% RDF), T_4:(50% spent wash + 50% RDF), T_5:(25% spent wash + 75% RDF), T_6: (50% spent wash + 50% FYM), T_7:(FYM 100%), T_8: (Control). The yield of cotton was significantly influenced by different treatment. The highest yield of cotton 23.89 q/ha was recorded with the application of 50 per cent spent wash + 50 per cent RDF, followed by slight decline in yield up to 23.06 q/ha with the addition of 25 per cent spent wash + 75 per cent RDF. The application of 100 per cent spent wash, 50 per cent spent wash + 50 per cent FYM and 100 per cent FYM reduced the yield of cotton significantly. The similar results were reported regarding stalk yield of cotton. The highest stalk yield (28.99 q/ha) was recorded in 50 per cent spent wash + 50 per cent RDF. The organic carbon was significantly increased from 4.0 g/kg as initial to 5.65 g/kg with an addition of 50 per cent spent wash + 50 per cent RDF followed by a small decline in O.C. up to 5.17 g/kg with addition of RDF alone and 25 per cent spent wash + 75 per cent RDF. The initial content of available N 160 kg/ha was increased significantly in all the treatment except application of 100 per cent FYM and control. The treatment T_4 recorded the maximum increase in available N up to 200 kg/ha followed by 190 kg/ha with the addition of 100 per cent RDF alone. The maximum increase in available P up to 18.60 kg/ha was noted with the addition of 50 per cent spent wash + 50 per cent RDF followed by 17.80 to 17.77 kg/ha with the application of 100 per cent RDF, 25 per cent Spent wash + 75 per cent RDF, respectively. The Treatment T_4 recorded maximum available potassium of 790 kg/ha at harvest of cotton. The content of micronutrients in soilwere influenced by addition of Spent wash. The highest available Mn was estimated in soil supplied with 75% spent wash + 25 per cent RDF. The initial content of available Zn 0.28 ppm was found to increase significantly in all treatments. The highest available Zn of 0.54 ppm was registered with the addition of 50 per cent spent wash + 50 per cent RDF.

2.35
e- Kapas – An Innovative ICT Model of CICR in Cotton Information Delivery

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Information and Communication Technology has immense potential to standardize and regulate agriculture process, address the needs of farmers and change the global scenario in reaching the clientele. Poor accesses to agricultural information are the major constraints in the growth of agricultural productivity in India. In the present era of knowledge revolution, with the advent of IT tools like computers, mobile phones and other facilities like video conferencing etc, lot of progressive dynamics are visible in human life. These ICT tools could be used efficiently for knowledge resource management in agriculture in order to address the knowledge gap among farmers, researchers and extension functionaries. Application and use of ICTs in agriculture sector puts forward hitherto untapped possibilities for knowledge access and utilization. It is in this context that the knowledge transferred should meet the immediate demand / priorities of the clientele in terms of knowledge, attitude, skills and practice. It is in this context e-Kapas network project ensures the availability of right information at right time at the doorstep of clients. ICAR-Central Institute for Cotton Research, Nagpur has introduced the novel extension mechanisms 'e-Kapas Network'project nationally from April, 2012. The project implemented with involvement of scientists of 18 participating centres in eleven cotton growing states of the country including three centres of CICR viz. Nagpur, Coimbatore & Sirsa and 15 AICCIP- SAUs centres provides opportunities to the cotton growers to get relevant, location specific, timely agro-advisory services and deliver appropriate cotton technologies to farmers to improve the efficiency of current manual system by saving time, money and making technologies available 'anywhere & anytime' to users. The system has become crucial in generating, disseminating and utilization of value added information for cotton related activities. The components of e- Kapas includes farmers' database , FAQs (Frequently Asked Questions) on cotton , content development & recording of voice messages, information delivery as voice calls on mobile numbers, kapas panchang and cotton apps. Information and knowledge delivery platform voice mail was used to provide agro-advisories to registered farmers on their mobile phones. Kapas Panchang in Hindi prepared by participating centre Shriganganagar and an Android Mobile Apps in Marathi developed by participating centre MAU Parbhani under 'e-Kapas' provides cotton information to the farmers on their local specific preferences and offer an apt solutions for the problems faced by the farmers. The paper discusses the results of voice based cotton information mobile delivery system implemented in cotton growing states for the farmers in nine local languages.

2.36

Rejuvenation of cotton in Koppal District: A case study of successful Extension strategy for rural socio economic upliftment

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Earlier to 2007, in Koppal district, area under cotton was only 50-60 acres with high cost of cultivation up to 30000 and lower yields of 15-17 q. at the time farmers were ignorant of Bt cotton and were of the thought that it might have adverse effect on the other crops being grown. So Krishi Vigyan Kendra, Gangavati took the initiative of convincing the farmers to go for Bt-cotton along with ICM practices. Front line Demonstrations on ICM practices were conducted with few interested farmers. Positive response was started bit late as they notice absolutely no incidence of bollworm. The approach resulted in creating positive impact on the growers so that the area under cotton increased enormously with high production which increased up to 40 q/ha as against 20 q/ha with a rise in productivity of 3215 kg/ha (1850 kg/ha earlier in non Bt cotton). Number of insecticide application reduced to 04 sprays in ICM plots as against 15 in non bt cotton and 07 in bt cotton with farmers practice. The indirect impact of bt cotton introduction was reopening of ginning mills in 2007 and started exporting 195 tonnes of cotton and 75 tonnes of wastes per year to other states. Before introduction of bt cotton it was only 91 and 20 tonnes per year. Earlier ginning mills used to offer 2-3 months employment to 20 labours in a year and now it rose up to 40 labors throughout the year.

2.37

Effect of commercially available nanofertilizers on yield attributing parameters and seed cotton yield

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Field experiment was conducted to study the effect of commercially available nanofertilizers on cotton growth and yield. Combined form of macro and micronutrient nanofertilizers like Richfield, Agriklik, Nualgi and Nanomol were purchased from different firms and then compared with normal recommended dose of combined form of normal micronutrient fertilizers which were sprayed on cotton (var: suraj) at 30 and 90 DAS. The results clearly revealed that Nanomol and Nualgi nanofertilizers application were on par on increasing the Seed cotton yield significantly (1407 and 1403 kg/ha respectively) which was followed by Agriklik (1383 kg/ha) and Richfield (1327 kg/ha) nanofertilizers. Combined application of normal micronutrients like zinc, iron, copper, manganese and boran increased the number of opened bolls and boll weight as compared to control but it was onpar with control (1257 kg/ha) on seed cotton yield. Overall, application of commercially available nanofertilizers considerably increased the number of opened bolls, boll weight and seed cotton yield as compared to normal recommended dose of micronutrients and control.

2.38
Studies on Integrated Nutrient Management in cotton Hybrid under High density planting system (HDPS)

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Cotton (*Gossypium hirsutum* L.), the 'white gold' or 'money spinner' enjoys a predominant position amongst all cash crops in India and cultivated since Indus civilization. India has the credit of the largest area under cotton (126.55 lakh ha) and ranks second in cotton production (400 lakh bales) during 2014-15.Telangana ranked third in area (1.65m ha) with production of 5 million bales. The crop in the region records a low productivity of 515 kg ha^{-1}.

Development of HDPS is to maximize yield potential, popularizing the system and facilitate mechanisation of cotton picking and harvesting Bt cotton in India.The adoption of HDPS, along with good fertilizer management is a viable approach to break the current trend of stagnating yield under rain fed hirsutum (upland) cotton growing areas. INM components are environment friendly. FYM improve the physical & biological soil condition besides improving soil moisture holding capacity especially true in rainfed areas. Thus, influence of FYM is of long term nature since it restores the sustainability of the soil-plant system. A field experiment was conducted to study the INM Practices on cotton hybrid (Monsanto-DPC 9109 BGII)crop was sown with spacing*i.e.,* 45 cm x15cm under rainfed conditions. The experiment was laid out in RBD design, replicated thrice on Alfisols during kharif 2015-16 in the College Farm, Rajendranagar. Data was recorded at three crop growth stages namely at 60, 90 DAS and at harvest.

The results shows that the performance of plants differed significantly under rainfed ecosystems of FYM @10/15 t ha^{-1}along with recommended dose offertilizer increased the Bt cotton yield and yield attributingparameters as compared to rest of the treatments and control plots.

Application of differnt fertilizer levels 270N-108P_2O_5-108K_2O kg ha^{-1} (180% RDF) the significantly improvedsympodia, LAI, dry matter and seed cotton yield(39.18 g m^{-1}) over the rest of NPK level. Where as lowest yield was recorded in control plot (i,e., with out FYM application) of 100N-60P_2O_5-60K_2O kg ha^{-1}(100% RDF) . Crop growth parameters,nutrient status,effects on soil with respect to enzymatic changes are diseussed.

CROP PROTECTION AND BIOSAFETY

3.1
Studies on population diversity of Pink bollworm, *Pectinophora gossypiella* Saunders (Gelechiidae; Lepidoptera) using SSR - molecular markers in cotton growing regions of southern India

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Laboratory experiments were carried out to study the population diversity of pink boll worm using SSR molecular markers in thirteen geographic locations of India *viz.*,, Tamil Nadu (Coimbatore, Salem, Perambalur, Madurai, Aruppukottai, Kovilpatti, Srivilliputhur, Veppanthatai, Chidambaram), Karnataka (Dharwad), Andhra Pradesh (Hyderabad), Delhi (Pusa) and Orissa (Orissa). Pink bollworm was collected from above mentioned regions for DNA isolation and DNA was isolated from right leg of female pink bollworm moth. Leg tissue was taken to avoid contamination (e.g. if the species eats other insects/ host). Three replications were maintained for DNA extraction. The genomic DNA was extracted following the alkali Lysis method. Quality and quantity of DNA samples were checked. SSR-PCR amplification and separation of amplified products by agarose gel electrophoresis were carried out. Analysis of SSR profiles were done with the help of AlphaEase® FC Software (Version 6.0) to find the per cent polymorphiosm. Results revealed that nine SSR primers screened produced clear bands and amplified a total of 101 alleles. The total number of alleles obtained from each primer ranged from 10 to 12 with an average of alleles/primer. All nine primers used in this study were found to be polymorphic and the polymorphism per cent was 100. The polymorphism information content for SSR primers ranged from 0.727 to 0.935. The size of amplification products ranged from 112 to 312 bp. The highest similarity index (0.875) was observed between Madurai and Srivilliputhur. The lowest similarity index (0.666) was observed between Perambular, Salem and Orissa to Coimbatore and between Orissa, Delhi to Kovilpatti. An UGPMA dendrogram based on similarity co-efficient was constructed for the 13 populations analyzed and two major clusters were evident. The first cluster contained pink bollworm population of Coimbatore and the second cluster had populations of remaining 12 locations and they are not diverse.

3.2
Effect of different sowing environments on cotton leaf curl disease and its vector whitefly and their relative progression

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Cotton leaf curl disease (CLCuD) is a potential threat responsible for low yield in cotton exclusively transmitted by its vector whitefly *(Bemisia tabaci)*. The present investigation was carried out at CCS HAU Cotton Research Station, Sirsa during the *kharif* 2014 to evaluate the relationship between CLCuD and its exclusive vector whitefly *(Bemisia tabaci)*. Four cotton cultivars *viz.,* 2 *Bt* cotton hybrids (SP7007 BG11 and Jai BG11) and two non *Bt* varieties (H1098 i and H1300) were sown at three different dates of sowing (29^{th} April, 14^{th} May and 27^{th} May). CLCuD first appeared in 27^{th} standard meteorological week and whitefly appeared in 26^{th} standard meteorological week. Per cent CLCuD incidence increased continuously from appearance to picking. Maximum per cent CLCuD incidence was recorded at end of 39^{th} standard meteorological week and simultaneously whitefly population was also recorded maximum on 39^{th} standard meteorological week. Early sowing (29^{th} April) found to be more appropriate to minimize CLCuD infestation having less per cent disease incidence and white fly population as compared to late sown crop (27^{th} May). In non *Bt* varieties less per cent CLCuD incidence and whitefly population also observed as compare to *Bt* cotton hybrids. In all the cotton cultivars, CLCuD incidence was positively related with whitefly population. A highly significant positive correlation was found between CLCuD incidence and whitefly population. It indicates that as the whitefly population increases CLCuD incidence also increases simultaneously.

3.3
Confirmation and maintenance of disease resistant lines against bacterial blight of cotton

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Cotton *(Gossypium* spp.) is one of the important commercial fiber and cash crop in India. India is an important cotton growing country with the largest area under cotton in the world and second as producer, consumer and exporter. This experiment was carried out to identify disease resistant line of cotton genotypes. Promising entries were selected on the basis of performance in AICRP trial screening during 2011-2012 and 2012-2013. Total 11 entries (6+5) *i.e.* BS 40, AKH 2006-1, P 2151, BGDS 801, BGDS 802, BS 47, BGDS 1063, NDLH 1943, BHV 180, AKH 10 1, SCH 1062 were screened against bacterial blight of cotton under epiphytotic condition to create disease pressure. The observations on bacterial blight were recorded by using 0 4 point prescribed grading scale. Among 11 genotypes, 5 genotypes were showed resistant to bacterial blight *i.e.* (P 2151, BGDS 801, BGDS 802, BS 47 and NDLH 1943) whereas 4 genotypes categorized on the moderately resistant *i.e.* (BS 40, AKH 2006 1, BHV 180 and AKH 10 1) remaining 2 genotypes were moderately susceptible to bacterial leaf blight of cotton *i.e.* (BGDS 1063 and SCH 1062).

3.4
Population dynamics of cotton whitfly (*Bemisia tabaci*) on different varieties of cotton in relation abiotic factors

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Post *Bt* release, the sucking pests *viz.,* whitefly, jassids, aphids, thrips and mites are causing much damage and gaining importance as compared to borer pests in both transgenic and non-transgenic cultivars of cotton in Punjab. Among these pests, whitefly (*Bemisiatabaci*) is causing extensive losses to cotton crop during the last 2-3 years in South western region of Punjab which is major cotton producing area. Higher incidence of *Bemisiatabaci*inFazilka district resulted in shifting of16.26per cent of the cotton area to other crops during the year 2015. White fly is vastly serious insect and constantly destabilizing the cotton production. The research was conducted to evaluate cotton cultivars (arboreum, hirsutum and transgenic) for resistance against whitefly and further correlated with weather factors such as temperature, relative humidity and rainfall, during the cropping season2015. During this year white fly attack started early (second week of June) with onset of early pre-monsoon showers in the area.However, peak population (71.77 adults/3 leaves) was recorded onAnkur-3028 followed by F-505 and F-1378, whereas minimum population was recorded onFDK-124 in arboreum group. The incidence and abundance was maximumduring first fortnight of August (70.74 adults/3 leaves) followed by second fortnight of July.FDK-124found relatively tolerant from all nine cultivars studied,followed by LD-694. However, Ankur-3028(transgenic) harboured maximum whitefly population and was highly susceptible as compared to arboreum and hirsutum cultivars. Correlation among weather factors and whitefly population showed that rainfall,relative humidity (both Minimum and maximum)and minimum temperature werepositively correlated while maximum temperature wasnegatively correlated with whitefly population in the region. Climatic conditions favours and helps in population buildup, abundance and incidence of whitefly.Here, resistant/tolerant germplasm can play an important role for managing the menace of whitefly and to revive the cotton cultivation in the region.

3.5

Inter relationship between abiotic factors and population dynamics of sucking insect pests in cotton

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Cotton, *Gossypium hirsutum* L., is one of the commercially important fibre crops in the world. Being cash crop, it provides livelihood to millions of people associated with its cultivation, textile and appareal industries but it attacked by large number of insect pests. These pests are responsible for reduction in quality and quantity of cotton. Abiotic factors affect the populations of insect pests, so in this study, field trial was conducted to determine the effect of ecological factors on the incidence and development of sucking insect pests under unsprayed condition on seven varieties of cotton (five were *Bt* with different gene construction BIOSEED 6588, NECH 6, JK 1947, SP 7007 and RCH 134, one non *Bt* hybrid HHH 223 and one non *Bt* variety H 1236). Experiment was done at Research Farm of Cotton Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar during *kharif* 2014. Observation on sucking insect pests (whitefly, leafhopper, thrips) were recorded at weekly intervals on three leaves selected randomly from each plant representing the top, middle and bottom portion of plant. They remained active throughout the crop season with little differences among them. It was observed that the whitefly was active from 24^{th} to 41^{st} standard meteorological weeks (SMW *i.e.* June to October) while leafhopper from 25^{th} to 41^{st} and thrips from 25^{th} to 40^{th} (SMW). Whitefly and leafhopper attained two peaks on 34^{th}, 39^{th} and 28^{th} and 33^{rd} SMW. However, thrips attained only one peak on 33^{rd} SMW. Whitefly and leafhoppers population were negatively correlated with maximum temperature, minimum temperature, average wind speed and with rainfall and positively correlated with RHm, RHe and sunshine hours. While thrips population showed positive correlation with temperature and negative with sunshine hours. There was found differences for sucking pests on the *Bt* and non *Bt* cotton genotypes. *Bt* genotypes attracted more population of whitefly as compare to non *Bt* genotypes.

3.6

Efficacy of newer insecticide against thrips and its impact on natural enemies in *Bt* cotton

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The field experiment was conducted to evaluate the efficacy of newer insecticides as foliar spray against thrips on *Bt* transgenic cotton during *kharif,* 2012-2013 at Cotton Research Unit, Dr. PDKV, Akola in randomized block design with eight treatments in three replications. The results revealed that Fipronil 5 SC (0.02%) was most effective treatment against thrips in transgenic cotton followed by imidacloprid

30.5 SC (0.005%) and diafenthiuron 50 WP (0.08%) which gave equal efficacy. The population of lady bird beetle, chrysopa larvae and spider in treated plots including control was in the range of 0.67 to 0.96, 0.70 to 0.97 and 0.70 to 0.95/ plant, respectively and the result revealed non significant differences amongst all the treatments. Highest yield of seed cotton was obtained from Fipronil 5 SC (0.02%) (12.22 q/ha), followed by imidacloprid 30.5 SC (0.005%), and diafenthiuron 50 WP (0.08%). Acetamiprid 20 SP (0.004%) was recorded highest ICBR (1:10.31) indicating most economically viable treatment followed Imidacloprid 30.5 SC (0.005) (1:10.13) followed by Acephate 75 SP (0.058%) (1:07:81).

3.7
Plant defence system against cotton leaf curl virus disease

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Cotton leaf curl disease caused by cotton leaf curl virus has been recognized as serious. However, combined information about plant secondary metabolism and minerals respond towards CLCuV is still limited. In this study activities of polyphenoloxidase and peroxidase with content of total phenol, sugar, gossypol, soluble protein and level of macro and micro nutrients were studied in leaves of healthy and diseased plant of H 1478, H 1098i, H 1156 and H 1462 genotypes. The amount of phenol, gossypol, and soluble protein was significantly higher in healthy plant as compared to diseased plant in all genotypes. Whereas, sugar content differs non-significantly and no consist pattern was observed among genotypes. The PPO and peroxidase activities was also found significantly higher in healthy plant in all genotypes and correlate with high amount of phenolic compounds. Potassium, manganese, zinc and sulphur were significantly less in diseased plant of all genotypes. Inconsistent pattern was observed among the genotypes in response to CLCuD for copper content. It differs significantly between healthy and diseased plants only in H 1156 and H 1462 genotypes. The high content of secondary metabolites and minerals in healthy plant leads to path for plant protection by means of their direct and indirect role against plant pathogen.

3.8
Integrated management of root knot nematode, *Meloidogyne incognita* on *Bt* cotton

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The successful raising of cotton is hampered by the attack of number of insect pests and diseases. The root knot nematode, *Meloidogyne incognita* (Kofoid and White) Chitwood is a major yield limiting factor in many countries including India. Management of this nematode on non *Bt* cotton is being tackled by various management components such as chemicals, botanicals, de oiled cakes and various bio control agents. So the present investigation was undertaken to have systematic and integrated approach comprising of soil and seed treatments for its management on *Bt* cotton (hybrid RCH 134). Soil treatments included carbofuran @ 1 kg a.i./ha and *neem* cake @ 20 g/kg soil, while seed treatments were carbosulfan (seed coating) @ 3.0 per cent a.i. w/w, seed soaking with carbosulfan @ 0.2 per cent, *Gluconacetobacter diazotrophicus* strain 35-47, *neem* seed kernel powder (NSKP) @ 2.0 per cent w/w, nimbicidin @ 2.0 per cent and *Trichoderma viride* @ 20.0 g/kg seed, either alone or in combination.

Sixty days after inoculation, the data indicated that maximum growth of cotton plants was observed in soil treatment with *neem* cake @ 20 g/kg soil followed by carbofuran @ 1 kg a.i./ha compared to untreated check. In case of seed treatments, plant growth was significantly improved in seed treatment with carbosulfan (coating), *G. diazotrophicus* and *T. viride*. Plant growth parameters were lowest and minimum in seed treatment with NSKP and nimbicidin. There was non-significant interaction between seed and soil treatments in case of plant growth. In case of soil treatment alone, nematode multiplication and reproduction was minimum in carbofuran followed by *neem* cake while in case of seed treatments, maximum reduction in nematode multiplication was noticed in seed coating with carbosulfan followed by seed treatment with *G. diazotrophicus* and *T. viride*. The interaction between seed and soil treatments was non significant except number of eggs and final nematode population. Minimum number of eggs and final nematode population was observed in soil treatment with carbofuran and seed coating with carbosulfan (3.0%) a.i. w/w.

3.9

Diversity of insect pests and natural enemies on transgenic and non transgenic *Bt* cotton

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Impact of transgenic cotton on the insect pests and natural enemies was assessed in the field in comparison with that of the non *Bt* cotton at Main Agricultural Research Station, UAS, Raichur and the results revealed that there was no difference in the egg laying pattern of *H. armigera* both in *Bt* (12.68/ plant) and non *Bt* (13.07/plant), the larval population was higher in number in non transgenic (9.18 larvae/ plant)compared to that of transgenic (2.88 larvae/plant) and also had lower boll damage in *Bt* cotton (7.68%) compared to that of non *Bt* cotton (44.61%) and higher seed cotton yield of 589.45 kg/ha and 172.13 kg/ ha in *Bt* and non *Bt* cotton respectively. Population of leafhoppers in transgenic and non transgenic cotton were 19.82/ 3 leaves and 11.64/ 3 leaves, respectively. With respect to natural enemies there was no significant differences were observed between transgenic and non transgenic cotton. The population of spiders were 4.85 and 5.16/plant on *Bt* and non *Bt* plants respectively. Whereas, the population of ladybird beetles and chrysopids in *Bt* cotton were 1.02 and 0.89/plant respectively but in non *Bt* the population of ladybird beetles was 1.19 per plant and chrysopids were 1.01/plant respectively. By the above mentioned results it is clear that there is no negative impact on the insect pests and natural enemies.

3.10

Survey for diseases and evaluation of cotton germplasm against Alternaria leaf spot disease

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Survey conducted during *kharif* 2012-2013 in ten villages of Guntur district revealed the highest incidence of Alternaria leaf spot (30%) followed by Cercospora leaf spot (12%), Tobacco Streak Virus disease (9per cent) and bacterial blight (5%) in Lam village. Grey mildew and rust diseases were not recorded at flowering stage. Intensity of Alternaria leaf spot, bacterial blight, grey mildew, Cercospora leaf spot and rust was to the tune of 12, 3.0, 6.6, 6.0 and 8.2 per cent respectively. The species associated with Alternaria leaf spot was identified as *Alternaria alternata* based on conidial characters. Among twenty popular varieties and hybrids evaluated at Regional Agricultural Research Station, Lam. Tulasi 144 BG II and U5-SS 33 BG II showed resistant reaction while Jadoo and Brahma recorded moderately resistant reaction against Alternaria leaf spot; eleven varieties *viz.,*, L 799, L 788, L 761, L 755, L 804, L 1011, L 1008, L 604, L

801, L 763 and L 808 were moderately resistant. Two hybrids KSPL (KDCCH 065) and NCS 9605 and three varieties *viz.,*, L 765, L 389, L 762 were moderately susceptible. One hybrid (SWCH 4746 BG II) and one variety *i.e.* Narasimha (NA 1325) recorded susceptible reaction to Alternaria leaf spot. In conclusion cotton farmers, may choose disease resistant hybrids as a component of integrated disease management to reduce cost of plant protection and thus reap maximum benefits.

3.11
Efficacy of systemic insecticides as stem application against sucking pests of *Bt* cotton

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The present investigation was conducted at Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri for four years during *Kharif* 2009 to 2012 to evaluate the efficacy of systemic insecticides as stem application against sucking pests of *Bt* cotton and it's effect on natural enemies of sucking pests. The stem application of carbosulfan 25EC (1:4) was found to be most effective against sucking pest of *Bt* cotton in which minimum of 8.09, 3.78, 7.97 and 5.90 aphids, jassids, thrips and whitefly/three leaves were observed with 20.88 quintal seed cotton yield/ha. This treatment was statistically *on par* with the treatments of oxydemeton methyl 25EC (1:4) and monocrotophos 36WSC (1:4), in which 8.61, 3.88, 8.22, 5.94 and 10.65, 4.19, 9.26, 6.37 aphids, jassids, thrips, whitefly/three leaves, respectively, were noticed. These treatments were recorded 20.12 and 19.39 quintal seed cotton yield/ha, respectively. The data on counts of *Coccinellids* and *Chrysopa* in different treatments was more or less similar to those recorded in untreated control which indicated that there were no adverse effects on natural enemies due to stem application of insecticides. The phytotoxicity studies on leaf injury on tips and leaf surface, wilting, vein necrosis, epinasty and hyponasty showed that there was no phytotoxic effect of evaluated pesticides on cotton crop at evaluated doses.

3.12
Effect of different whitefly, *Bemisia tabaci* (Gennadius) management schedules on its parasitization on cotton

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The experiment was carried out on cotton crop during *kharif* 2014 at the Cotton Research Farm, Department of Genetics and Plant Breeding, CCS HAU, Hisar. The observations *on par*asitization of whitefly by its parasitoids were recorded at 7, 14 and 28 days after end of spray schedules. Effect of seven insecticides, namely, nimbecidine (azadirachtin 0.03per cent) @ 1litre, dimethoate 30 EC @ 300ml, thiamethoxam 25WG

@ 40g, triazophos 40 EC @ 600ml, novaluron 10 EC @ 200ml, urea + DAP + Zn @ 2.5kg + 2.5kg + 0.5kg, imidacloprid 17.8 SL @ 40ml and yellow sticky trap (3cm×5cm)(no.) @ 50 per acre was tested under field conditions *on par*asitisation of whitefly. *Bt* cotton Bio 6588 BG II was sown during second fortnight of May by following recommended agronomic practices. The plot size was 81 m^2 with three replications for each schedule. Spraying was initiated as soon as pest attained economic threshold. Thirty full grown leaves per replicate of each treatment were plucked randomly and brought to the laboratory for examination under stereozoom binocular microscope for presence of parasitized pupae of whitefly. Healthy and parasitized pupae were counted and per cent parasitization was worked out. Parasitization ranged from 51.75 per cent to 88.43 per cent during August to September. Mean pupal parasitization was maximum (74.79%) in a management schedule consisting of six sprays of nimbecidine (azadirachtin 0.03% @ 1l/ac) at five days interval and a yellow stick trap placed in the plot followed by (70.82%) in a schedule of six sprays of nimbecidine at five days intervals only. The minimum parasitization (56.47%) was recorded in a schedule consisting of six sprays at five days interval each of dimethoate followed by imidacloprid, thiamethoxam, dimethoate, imidacloprid and thiamethoxam. It was concluded that different management schedules had significant effect *on par*asitization of whitefly pupae by *Encarsia* spp and nimbecidine was found relatively less toxic and much safer to the natural enemies than other insecticidal treatments.

3.13
Impact of insecticide resistance management strategies on cotton insect pest in districts of Rajasthan

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Cotton is an important fiber crop. About thirty insect pests starting from seedling to harvesting, attack cotton crop in Rajasthan. During survey on insect faunal complex of cotton in semi arid plain of Rajasthan, fourteen insect pests were recorded on cotton in the zone. Among the sucking pests, aphid (*Aphis gossypii* Glover), leafhopper (*Amrasca biguttula biguttula* Ishida), thrips (*Scirtothrips dorsalis* Hood) and whitefly (*Bemisia tabaci* Gennadius) attack at early vegetative stage of the crop, while bollworms *viz* spotted bollworm (*Earias vittella* Fabricious) and (*Earias insulana* Boisdual), American bollworm (*Helicoverpa armigera* Hubner) and pink bollworm (*Pectinophora gossypiella* Saunders) are the most damaging at reproductive stages of the crop. In the years of pest favourable climatic conditions, the cotton growers have to go repeated number of chemical sprays resulting in not only increase in the cost of cultivation but also imbalance in the cotton agro eco-system. So to make the cotton production profitable, efforts were made for developing I.R.M. strategies module on cotton. Fields experiments conducted on I.R.M. from the period 2002 to 2011 produced better results for lower pest population, pest incidence, pesticidal exposure and in return higher conservation of bio agents, seed cotton over chemical spray schedule. The components used under I.R.M. were variety resistant/tolerant to insect pests and adoption of cultural, mechanical, biological and chemical methods of pest control. In IRM fields, for keeping the population of insect pest under control, multiple suppression techniques were used involving resistant varieties like Bioseed 6588, Bioseed 6488, MRC 6317 etc., sanitation practices and need based application of insecticides developed for control of insect pest to conserve natural enemies of insect pests. In cultural and mechanical control physical barriers, removal and burnt of all crop residues in previously infested fields, eradication of weeds and deberies, remove alternate host of insects. Avoid use of any insecticidal sprays first sixty days after sowing to protect natural enemies and also use 5 per cent NSKE for sucking pests. The overall of ten years (2002 to 2011) number of sprays in IRM farmers field were 5.64, whereas non IRM farmers sprayed 8.52 times. The per cent reduction in number of sprays and cost of sprays was 32.86 and 24.46 respectively. IRM plots produced 16.52 per cent (302 kg/ha) more seed cotton yield than non IRM.

3.14
Population dynamics of major sucking pests of cotton and its relationaship with weather factors

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Cotton is an important commercial crop of India and is grown in three agroclimatic zones of India. Genetically modified cotton (*Bt* cotton) has a huge impact on cotton production and many studies have been focussed on its positive impact while the emergence of new and secondary pests has been ignored. In order to get benefits of *Bt* technology it is necessary to be aware of the emergence of new and secondary pests and their management. Hence, studies on population dynamics of major sucking pests in *Bt* cotton and their correlation with weather parameters were conducted during 2014-2015. Sucking pests *viz,* whitefly, leafhopper, and thrips remained active throughout the cropping season of cotton. Two peaks of population of whitefly 49.25 and 62.51 adults/leaf were observed during the 34^{th} and 39^{th} Standard Meteorological Week (SMW). Among the genotypes screened, maximum whitefly population was 54.04 (PCH 401 *Bt*) and 78.31 adults/leaf (KSCH 209 BG II) during first and second peak, respectively. Leafhoppers irrespective of genotypes attained two peaks during the 28^{th} and 33^{rd} SMW with their mean population 4.79 and 6.69 nymphs/leaf, respectively. The maximum population (6.80 nymphs/leaf) was recorded in SP 7007 genotype whereas genotype RCH 314 had lowest (3.83 nymphs/leaf) population during first peak. However, during second peak, genotype NCS 9002 BG II and Western Nirogi 151 BG II genotype showed minimum (2.70 nymphs/leaf) and maximum (4.21 nymphs/leaf) population, respectively. Maximum thrips population was observed on 33^{rd} SMW with mean value 11.29 thrips/leaf. Minimum population during this period recorded in NECH 6 (6.36 thrips/leaf). RCH-134 *Bt* genotype recorded maximum seasonal population (6.71 thrips/leaf) while it was minimum in Western Nirogi 151 BG II genotype (3.5 thrips/leaf). It was also observed that weather parameters directly affected the population of sucking pests. Whitefly and leafhoppers population were negatively correlated with temperature, wind velocity and rainfall and positively correlated with RH and sunshine hours.

3.15
Effect of different weather parameters on development of Alternaria blight of cotton

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The data on different weather parameters and Alternaria blight incidence on experimental farm of Cotton Improvement Project, M.P.K.V., Rahuri was recorded for 10 years *i.e.* from 2001 to 2010 seasons and based on this available data linear regression model was developed for effective prediction of the Alternaria blight of cotton during the crop growth period . The studies revealed that the minimum temperature, morning relative humidity (RH I) and rainfall contributed significantly for the disease infection and its spread. Further, the percent disease index (PDI) has progressed at linear rate throughout the plant growth up to MW 41 after which it started to decline. The data was subjected to step down regression by eliminating the non significant factors and including only significant factors for predicting the incidence of Alternaria blight of cotton under scarcity zone of Maharashtra using linear model. By employing step down linear regression model, the incidence of Alternaria blight of cotton can be predicted to an extent of 77per cent accuracy. The following equation representing the relationship between *Alternaria* leaf blight incidence on cotton and the weather parameters (T_{min}, RH I and RF) is recommended ‘for use in predictive forewarning model’ in scarcity zone of Maharashtra.

3.16
Pink bollworm, a serious threat to cotton cultivation in Gujarat

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Area wise Gujarat ranks second while production wise its position is still at top amongst different states of India. Gujarat has witnessed increase in area to sixty-nine per cent and productivity to 50 per cent since 2002. Though, *Bt* cotton helped farmers to save significant damage to fruiting bodies by three bollworms (*Helicoverpa, Earias* and *Pectinophora*) for a decade; the sustainability is at stake due to mealybug, leaf reddening, parawilt and recent pink bollworm infestations in parts of Gujarat. The probability of gradual increase in resistance to Cry 1 Ac gene cautioned technology provider to expedite the launch of two gene technology (Cry 1 Ac + Cry 2 Ab) in 2006 so as to combat resistance build up in targeted bollworms. The outbreak and damage of pink bollworm even on *Bt* cotton in late season (November-December) in major cotton growing area of four districts of Saurashtra region in 2010 triggered the practical withdrawal or sale of Bollgard *Bt* cotton across the state. This was followed by large scale commercialization of Bollgard II. Even this strategy seems to be affected badly as severe pink bollworm outbreak and damage was observed during September to December in early sown cotton at coastal cotton growing areas of Saurashtra and south Gujarat in *kharif* 2014. Recent outbreak and damage (*kharif* 2015) to flowering in early sown *Bt* cotton in south and middle Gujarat as well as Saurashtra region was of serious concern. Rearing and bioassay studies of pink bollworms at CICR, Nagpur and Coimbatore confirmed the survival of pink bollworm on BG II cotton hybrids. Reasons for severity of pink bollworm incidence on *Bt* cotton in Gujarat are briefly discussed. Recent outbreak of pink bollworm necessitates systematic research to formulate future strategies.

3.17
Relative incidence of pink bollworm on *Bt* and non *Bt* cotton hybrids under integrated pest management and unprotected conditions

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A field study was conducted to know the seasonal dynamics of pink bollworm, *Pectinophora gossypiella* (Saunders) on two *Bt* cotton hybrids (MECH 12 *Bt* and RCH 2 *Bt*) along with their non *Bt* counterparts (MECH 12 non *Bt* and RCH 2 non *Bt*) under IPM as well as under unprotected conditions at RARS, Lam, Guntur for two consecutive seasons. The genotypes were sown during first fortnight of July in a plot size of 200 sq m each and all the agronomical practices were followed as per recommendations of ANGRAU. One block was maintained with recommended IPM package of ANGRAU and one block was maintained completely under unprotected conditions for each hybrid. The incidence of pink bollworm larvae was recorded from 90 days after sowing onwards from all the hybrids by destructive sampling of the green bolls *i.e.*, 50 bolls were picked up randomly from each of the test hybrid plot which were cut open in the laboratory and larvae/ boll was recorded. The data obtained from two *Bt* hybrids and their two non *Bt* counterparts from two seasons was pooled for analysis. The incidence of pink bollworm larvae was observed from first week of November (45^{th} standard week) in non *Bt* hybrids under both IPM and unprotected conditions. Whereas, the incidence of pink bollworm was observed from second week of December under unprotected conditions and it was from fourth week of December under IPM in *Bt* hybrids. However, the incidence of pink bollworm larvae was almost negligible in *Bt* hybrids when compared to their non *Bt* counter parts both under integrated pest management and unprotected conditions. The average larval incidence was only 0.04 and 0.11/boll in *Bt* hybrids, while it was 0.52 and 1.31/boll in non *Bt* hybrids under IPM and unprotected conditions, respectively. The present study clearly indicating that the adoption of IPM in *Bt* cotton not only helps in reducing the sucking pests incidence, but also helps in suppression of the survived larval population of bollworms, which inturn increases the sustainability of *Bt* cotton cultivation.

3.18
Efficacy of fungicides and bioagent cotton foliar diseases of against

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A field experiment was conducted during year 2013-2014 to integrated disease management strategy involving chemical and biological fungicides to control cotton foliar diseses. The experiment was conducted at Cotton Research Station, Nanded under rainfed condition and was laid out in randomized blocked design with three replication and spacing 60 x 30 cm.
The LRA5166 highly susceptible check was tested in comparison with bio efficacy of foliar spray of 5 fungicides 1) copper oxychloride 25g/10l 2) Streptocycline 2g/10l 3) carbendazim10g/10l 4) Hexaconazole 3ml/10l 5) mancozeb 25g/10l and three biocontrol agent 1) *Trichoderma virideae* 4g/10l 2) *Pseudomonas fluroscens* 20g/10l 3) *Trichoderma harzainium* 4g/10l were evaluated against cotton foliar diseses. Three sprays were applied against cotton foliar diseses. With combination of copper oxychloride 25g/10l + Streptocycline 2g/10l and one control. Five plants from each plot were selected randomly for recording observations on foliar diseses. The results reveald that the control of bacterial blight in cotton the combination of copper oxychloride 25g/10l + Streptocycline 2g/10l (3.33PDI) and for control of *Alternaria* as well as grey mildew disease carbendazim10g/10l (5.33 PDI) 4.25, PDI was found superior respectively.

3.19
Screening of breeding materials for their reaction to key pests of cotton

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A field experiment was conducted during year 2014-2015 with an objective to screen the strains for better tolerance/resistance against major pests of cotton for minimizing the plant protection schedule. The experiment was conducted at Cotton Research Station Nanded under rainfed condition and was laid out in randomized block design with three replication and spacing 60 x 60 cm. there are 24 strains were tested against major pests of cotton. In general the in cadence of sucking pests was moderate to high jassids (16.13/3 leaves), whiteflies (14.70/3 leaves) whereas bollworm was low to medium (22.60 percent) during the crop season. The strain IH 11 recorded Jassid population (4.23/3 leaves), whiteflies (5.60/3 leaves), open boll damage (7.77%), locule damage (4.37%), good opened bolls (60 bolls) and yield 9.10 q/ha . The strain GBHV 177 recorded highest jassid population (4.67/3 leaves), whitflies (5.67/3 leave), good opened bolls (49 bolls) and yield (6.49 q/ha)and NHH 715 recorded highest jassid population (5.10/3 leaves), whiteflies (7.30/3 leaves), good bolls (60 bolls) and yield recorded (6.59 q/ha) were found promising since they have recorded low incidence of pests damage and also recorded more number of bolls and higher seed cotton yield.

3.20
The efficacy of insecticides against sucking pest of cotton

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A field experiment was conducted during year 2014-2015 with an objective to revalidation of existing recommendation of insecticides against sucking pest of cotton. The experiment was conducted at Cotton Research Station, Nanded under rainfed condition and was laid out in randomizing block design with three replication at spacing of 90 x 60 cm. The Hybrid RCH 2, BG II were tested in comparison with bio efficacy of foliar spray of four insecticides 1) Buprofexin (25%) SC 250 gai/ha 2) Flonicamid (50%) WG 75 gai/ha 3) Flonicamid (50%) WG 100 g a.i./ha 4) Fipronil (5%) SC 87.5 g a i/ha 5) Fipronil (5%) SC 50 g a i/ha 6) Diafenthiuron (50%) WP 300 g a.i./ha and three bio control agent 1) NSKE (5%) 2) V. Lacanii 5g/l 3) Metarhizium anisopliae 3g/l were evaluated against sucking pests of cotton. Three sprays were applied against sucking pests for efficacy. Five plants from each plot were selected randomly for recording observations of sucking pests. The observations were recorded before spray, 7th and 14th days after each spray against sucking pests.

The results indicated that the overall mean population of aphids after three sprays was delivered considerably in all treatments except metarhizium anisopliae and control plots. The lowest population of jassds (2.44 / 3 leaves), thrips (5.41 / 3 leaves) and whiteflies (4.01 /3 leaves) and the highest seed cotton yield 8.77 q/ha recorded in Flonicamid 75 gai/ha . However, the seed cotton yield reduced in treatments Fipronil 87.5 g a.i./ha and 50 gai/ha (6.35 and 5.34 q/ha), respectively due to mealy bug and jassid populations above ETL.

3.21
Screening of *Gossypium hirsutum* genotypes for disease reaction in the south western region of Punjab

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Cotton leaf curl virus disease (CLCuD) is a major limiting factor in cotton production which first appeared in patches during 1993 around Sriganganagar district of Rajasthan and Ferozpur district of Punjab adjoining to Pakistan border on *G.hirsutum* and later on spread to entire North India in a short span of 4-5 years. Bacterial blight (Bb) caused by bacteria *Xanthomonas axonopodis* pv.*malvacearum* and the fungal foliar leaf spot (FFLS) caused by fungi *Myrothecium* sp and *Cercospora* sp is also the diseases of prime concern in cotton. The incidences of the diseases are widespread and their severity is further increased and now it becomes a great threat to cotton cultivation in the region. Research efforts were done to screen the existing genotypes of *G.hirsutum* against the prevalent diseases of cotton.

Twenty eight genotypes of *G.hirsutum* were screened along with the susceptible check (F 846) for the disease reaction in cotton *i.e.* cotton leaf curl virus disease (CLCuD), bacterial blight (Bb) and fungal foliar leaf spot (FFLS) at Punjab Agricultural University, Regional Station, Bathinda during 2014-2015.
Among the twenty eight genotypes, none of the genotypes of *G. hirsutum* was found to be completely free or resistant from cotton leaf curl virus disease (CLCuD). However, seven genotypes of *G. hirsutum i.e* CSH 3088, LH 2232, F 2164, FHH 209, FHH 231, HHH 494 and F 2381 showed moderate degree of resistance (MR) with the per cent disease index of 27.77, 21.60, 27.77, 26.47, 29.41, 22.05 and 28.42, respectively. The rest of the genotypes were found to be susceptible/moderately susceptible/ highly susceptible in nature whose PDI varied from 31.25 to 59.32.
All the tested genotypes of *G.hirsutum* have shown the resistant(R) reaction against the bacterial blight (Bb) and fungal foliar leaf spot (FFLS). The genotypes found to be the resistant/moderately resistant can be used for further screening in the south western region of Punjab.

3.22

Impact of new molecules on bollworm management in cotton under high density planting system

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The field experiment was conducted at Central Institute for Cotton Research; Nagpur, during *kharif* 2014-2015; to study the effects of different window based spraying for the management of boll worms under high density planting system (HDPS) adopting 45 x 10 cm spacing. The experimental field (Lat 21° 2' 18.4704'' N, Long 79° 3’36.6912’’E) of cotton (*Gossypium hirsutum* L, var.,Suraj) had medium deep black soil. Five *viz.,,* insecticides like Clorantraniliprole 18.5 SC, Flubendiamide 480 SC, Spinosad (45%) SC, Indoxacarb 14.5 SC and Emamectin benzoate (5%) SG. were sprayed in different windows 60DAS, 60and 80DAS, 60, 80 and 100DAS, 60, 80 100DAS and 120DAS, 100 and 120DAS, 80,100 and 120DAS, 120DAS only, 80DAS only, 100DAS only, an unsprayed control was also maintained. Among the five insecticides Clorantraniliprole 18.5 SC and Flubendiamide 480 SC was recorded lowest incidence of bollworm at 60 DAS and 80DAS. The effect of new molecules on Coccinellids and Spider population was recorded as non significant at 60, 80,100 and 120DAS as compared to the untreated control under HDPS.

3.23
Bioefficacy of insecticides against sucking pest in *Bt* cotton

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Cotton is unanimously designated as “King of fibres” as it tops the table depicting the statistics of fibre crops. As a leading commercial crop it is grown world wide. India occupies largest area and third place in the production of cotton in the global scenario. Major constraint in attaining high production of seed cotton is damage inflicted by insect pests. About 96 insect pests attack cotton cropand the estimated loss due to sucking pests is up to 21.20per cent. Newer chemistries of pesticides have raised the hopes for better management of dreaded pest world wide. Hence, investigations was carried out to assess the bio efficacy of insecticides against sucking pest in *Bt* cotton using different chemical component, NSKE and some biopesticide during 2014-2015 under irrigated conditions at Cotton Research Station, Srivilliputtur. In this bioefficacy study, the treatment was imposed the Buprofezin 25 SC @250 g a.i./ha , Flonicamid 50 WG @ 75 g a.i./ha , Flonicamid 50 WG @ 100 g a.i./ha ,Fipronil 5 SC @ 87.5 g a.i./ha , Fipronil 5 SC @ 50 g a.i./ha ,NSKE 5per cent, Diafenthiuron 50 WP@300 g a.i./ha *, Lecanicillium (Verticillium) lecanii*@5g/l, *Metarhizium anisopliae*@5g/l and Untreated check. In respect of two spraying, Flonicamid 50 WG @ 100 g a.i./ha (leaf hopper 1.12 /3 leaves, whitefly 0.9 /3 leaves, thrips 1.48/3 leaves), Diafenthiuron 50 WP@300 g a.i./ha (leaf hopper 1.98 /3 leaves,whitefly 0.92 /3 leaves, thrips 1.12/3 leaves), Fipronil 5 SC @ 87.5 g a.i./ha (leaf hopper 1.72 /3 leaves,whitefly 0.83 /3 leaves, thrips 1.42/3 leaves), and Buprofezin 25 SC @250 g a.i./ha (leaf hopper 1.83 /3 leaves,whitefly 1.03 /3 leaves, thrips 0.98 /3 leaves)was found to be highly effective followed by other treatment over by untreated check and the cotton *kapas* yield was highly recorded in Diafenthiuron 50 WP@300 g a.i./ha (13.68 q/ha) and statistically *on par* with Fipronil 5 SC @ 87.5 g a.i./ha (13.49 q/ha),Buprofezin 25 SC @250 g a.i./ha (12.17 q/ha),Flonicamid 50 WG @ 100 g a.i./ha (11.98 q/ha) followed by other treatment over the untreated check (7.63 q/ha) for the sucking pest like leaf hopper, whitefly and thrips in *Bt* cotton.

3.24
Biochemical changes in cotton plant due to infestation by cotton mealybug, *Phenacoccus solenopsis* Tinsley ((Hemiptera: Pseudococcidae)

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The study on biochemical changes in cotton plant due to infestation by cotton mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) was conducted at CICR Nagpur during 2014-2015. Total protein contents estimated from the shoots of the healthy and infested cotton plants shows significant difference. The increase in total protein content was recorded as high as 50.52 % in the mealybug infested cotton plant (4.29±0.24mg/g) over the healthy cotton plant (2.85 ± 0.43mg/g). The infestation by *P. solenopsis* resulted increase in the total phenol content in the mealybug infested plants (0.19 ±0.03 mcg/g) over the healthy cotton plants (0.07 ± 0.01 mcg/g). The level of total soluble sugar was increased marginally by 11.11 per cent in the mealybug infested plant (1.00 ± 0.35 mcg/g) but was not statistically different as compared to healthy cotton plant (0.90 ± 0.28 mcg/g). Total photosynthetic pigments were estimated using leaf of the mealybug infested and healthy cotton plant. Though there was depletion in all the photosynthetic pigments *viz.*, chlorophyll a, chlorophyll b, total chlorophyll and carotenoids due to the mealybug infestation however, values were not statistically different than the values of healthy cotton plants. The decrease in photosynthetic pigments chlorophyll a, chlorophyll b, total chlorophyll and carotenoids was 21.70 per cent, 11.56 per cent, 21.42 per cent, 17.54 per cent, respectively.

3.25

Yield loss estimation due to cotton leaf curl disease (ClCuD) in south western Punjab

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Cotton leaf curl disease (CLCuD) is potentially the most important disease of cotton in South Western Punjab. This disease is characterized by upward and downward curling of leaves, thickening of veins on the underside of leaves. The appearance of the disease at seedling stage seriously retards the overall plant growth. The disease is caused by whitefly transmitted geminiviruses. To study the yield loss in cotton crop, experiments were conducted on popular *Bt* hybrids cultivated in the region. The yield loss estimation was recorded at Punjab Agricultural University, Regional Station, Faridkot for two successive seasons *Kharif*-2013 and 2014. The results revealed that the number of bolls per plant and seed cotton yield reduced as the CLCuD grade increased in all the four hybrids namely RCH 134 BG, Ankur Jai BG II , NCS 855 BGII and RCH 134 BGII. However, reduction in boll/plant was 41.05 per cent followed by 39.9 per cent, 34.4 per cent and minimum was 30 per cent, respectively. Similarly, reduction in seed cotton yield was 37.6 per cent followed by 35.6 per cent, 39.05 per cent and 26.6 per cent in NCS 855 BG II, RCH 134 BG II, RCH 134 BGII and in Ankur Jai BG II, respectively in *kharif* 2013. In *kharif* 2014 boll/plant reduced by 52.16 per cent followed by 42.56 per cent, 37.38 per cent and 36.07 per cent. The seed cotton yield also reduced from 55.86 per cent, followed by 45.94 per cent, 39 per cent and 37.29 per cent in NCS 855 BG II, RCH 134 BG , RCH 134 BGII and in Ankur 3028 BG II, respectively in *Kharif* 2014. The data for both the years revealed that number of Bolls/plant and seed cotton ield in all the hybrids decreased. The plants were tagged and were observed for number of opened bolls and yield losses due to CLCuD. The disease severity was assessed on a scale of 0 – 6.

3.26
Shifting dynamics of cotton whitefly (*Bemisia tabaci*) under prevailing weather conditions in Faridkot district of Punjab

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In Northern India, the outbreaks of mealybug during 2007 and whitefly during 2010 and 2015 caused huge yield losses and crop failure of bt cotton. The upsurge in the population of sucking insect pests such as whitefly, leafhopper and thrips has posed a serious threat to cotton cultivation. Whitefly populations are largely regulated by the climatic factors viz. temperature, rainfall and humidity. During 1994-2004, maximum whitefly population was recorded in the month of September (*i.e.* 37-41st standard weeks) but the trend shifted after introduction of transgenic cotton. During 2006 to 2009, the whitefly population remained almost below ETL; however, the year 2010, hottest in the last decade, recorded higher population July onwards. The population of whitefly remained above ETL in *Bt* hybrid (RCH 134) from July till September, however on sucking pest susceptible cultivar Ganganagar Ageti, it remained above ETL from June till September. The higher incidence of the whitefly is being observed after one month of sowing *i.e.* the peaks have shifted from 32 -39 to 25 to 33 standard week post *Bt* cotton introduction, especially 2010 onwards. The population existed above ETL throughout the season during last three years (2012-2014). The whitefly appeared in epidemic form in year 2015 making its appearance June end onwards. To understand the pest-weather relationship, correlation coefficient (r) between the whitefly population and weather variables was worked out using the pest and weather data starting from 25 to 35 standard weeks for the years 2007-2015. The correlation results depicted that whitefly population at early stages (25-26 MSW) would increase with increasing thermohumid conditions but at later stages, the high temperature was harmful and relative humidity (r=0.987*) was again beneficial. For relatively long period, overcasted sky with minimum or no bright sunshine duration along with the light rain showers supposed to be the comfortable conditions for this pest which prevailed this year (2015). The rainfall have detrimental effects on pest population over the period with high correlation coefficients (r=-475 at 25 SMW to r=-992**). Similarly, the significantly high negative correlation (r=-89* at 26 standard week to r=-963** at 35 standard week) described the inverse relationship between number of rainy days and pest population. Overall increase in the sucking pest populations after the introduction of *Bt* cotton could be attributed to the reduced pesticide application in initial years, multiplicity of bt hybrids, high nitrogen use in bt hybrids but the role played by the climatic factors cannot be ignored. These weather variables can be helpful in developing forewarning models that can further serve as a platform for devising the insect pest management strategies.

3.27

Status of insecticide resistance in leafhopper, *Amrasca biguttula biguttula* (Ishida) on cotton

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Laboratory studies were carried out to investigate the development of resistance towards recommended insecticides in cotton leafhopper, *Amrasca biguttula biguttula* collected from four different locations *viz*., Ludhiana, Muktsar, Mansa and Abohar of Punjab. Five insecticides *viz*., imidacloprid, acetamiprid, dimethoate, monocrotophos and triazophos were tested. Among different populations, Abohar population was found to be the least susceptible with LC_{50} values ranging from 0.0020-0.0496 per cent whereas Ludhiana population was found to be more susceptible with LC_{50} values ranging from 0.0012-0.0255 per cent to all the insecticides tested. Among different insecticides, imidacloprid with LC_{50} values ranging from 0.0012 to 0.0020 per cent showed maximum toxicity followed by acetamiprid, dimethoate and monocrotophos while triazophos was found to be least effective insecticide with LC_{50} values ranging from 0.0255 to 0.0496 per cent. Small differences in the susceptibility from the baseline LC_{50} values against all the tested insecticides indicated that there are no serious levels of resistance (2.12-5.11 x) in *A. biguttula biguttula* with respect to these insecticides in Punjab.

3.28

Role of morpho-physical and biochemical plant factors imparting resistance in cotton against sucking pests

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Fourteen genotypes of cotton (*Gossypium hirsutum* L.) were selected for field screening studies against sucking pests at Regional Agricultural Research Station, Lam, Guntur during the year 2013-2014. Morphological characters like leaf thickness and hair density of cotton leaf, biochemical characters *viz.,* phenol, tannin and gossypol were quantified for these fourteen cotton genotypes to find out the characters of cotton plant that associated with tolerance or resistance to sucking pests. The study revealed that, the genotypes with highest leaf hair density had shown lowest leafhopper injury index and recorded as resistant genotypes. Resistant genotypes showed higher quantity of biochemical components like tannins, phenols and gossypol at vegetative stage compared to reproductive stage. Genotypes like L 603 and NDLH 1938 were recorded as

resistant genotypes with the highest leaf hair density of 163.44, 154.17 per 0.45 cm diameter leaf disc, respectively. LK 861 was highly susceptible genotype with the lowest hair density of 13.06 per 0.45 cm diameter leaf disc. Similarly the genotypes NDLH 1938, L 603 and NA 1325 recorded more biochemical components among the genotypes screened and were reported as resistant to sucking pest complex. The highest seed cotton yield was observed in NDLH 1938 (20.28 q/ha), L 603 (19.75 q/ha), NA 1325 (18.87 q/ ha), MCU 5 (18.52 q/ha) and Sivanandi (18.28 q/ha) among the fourteen genotypes which were found to be leafhopper resistant.

3.29

Management of sucking pests in cotton using low cost stem applicator (Cotton gun)

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Cotton, commonly called as 'White Gold' plays significant role in nation's agricultural economy through exports besides meeting the local textile requirements. The area under cotton is increased from 13,690 ha in 2013-2014 to 16,890 ha during 2014-2015 in east Godavari District of Andhra Pradesh. After the introduction of *Bt* cotton, the boll worm menace was replaced by sucking pests like jassids, aphids, whitefly and mealy bugs causing moderate to severe yield loses. Generally farmers go for repeated application of plant protection chemicals as foliar sprays. Considering the deleterious effects insecticides, the scientists of ANGRAU have developed stem application technique for managing early season sucking pests in cotton.

Stem application is a safe and judicious pesticide usage technique, wherein spot application of the pesticide will be done on the stem with the help of a brush or cotton wicked bottle. This technique proved effective and saved more than 50-60 per cent of the chemical required and found safe to the natural enemies and other non-target organisms but could not gain much popularity among the cotton farmers due to the drudgery involved in application and it is also time consuming. Taking these flaws into consideration, Scientists of ANGRAU have developed a low cost stem applicator called, **"Cotton Gun"**. In order to popularize the stem application technique, we have conducted "On Farm Trials" on management of sucking pests in cotton using stem applicator (cotton gun) with monocrotophos at 30 and 45 days after sowing (DAS), imidacloprid at 60 DAS during *kharif*, 2014 in Tatiparthi village of Gollaprolu (M) of east Godavari District, with same package of practices in trial plot and control plot (Farmers practice) except plant protection measures. The results showed that there was an increase in the yield to the extent of 4100 kg/ha (5.8%) over the farmers practice (3875 kg/ha) with a direct reduction in the cost of plant protection up to Rs.3750/ha. The number of sprayings was reduced to three against six in control plot. The Benefit Cost ratios were 2.83:1 and 2.48:1 in trial plot and control plot respectively. Thus, management of early season sucking pests by adopting stem application technique using stem applicator up to 70-75 days after sowing(DAS) followed by need based application of insecticides at later stages of cotton crop gave best results over farmers practice, besides reducing drudgery and saving time.

3.30
Evaluation of insecticides against major sucking pests of cotton

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The trial was conducted for Evaluation of insecticides against major pests of cotton at Regional cotton research station Khandwa during 2012-13. JK-4 verity of cotton was sown on 30.06.2012. Seven treatments were replicated thrice against Sucking pest Aphid, Jassid and White fly. The three spray of four insecticides Sulfoxaflor 24% SC @ 75 & 90 gm ai./ha, Flupyradifurone 20 SL @ 200 & 250 gm ai./ha, Imidacloprid 200 SL 40 gm ai./ha and Acephate 75 sp 562.5 gm ai./ha with untreated control evaluated for bioefficacy . All treatment perform well over control.
Minimum Aphid population/3 leaves (5.11) after 3rd spray was recorded in Flupyradifurone 20 SL @ 250 gm ai./ha, and followed by Flupyradifurone @ 200 gm ai./ha.
The highly effective insecticide against white fly was Sulfoxaflor 24% sc@ 90 gm ai./ha with significant minimum population (1.17 / 3 leaves) and followed by Flupyradifurone 20 SL @ 250 gm ai./ha and Sulfoxaflor 24 % SC. . Sulfoxaflor 24 SC and Flupyradifurone 20 SL both nwere recorded significant effective against jassid.
Flupyradifurone 20 SL was less harmful and at par with untreated control or Coccinella and Chrysopa species. The highest yield 1353.52 Kg/ha was recorded in Sulfoxaflor 24 sc @ 90 gm ai./ha followed by Sulfoxaflor @ 75 gm/ai, Flupyradifurone @ 250 and 200 gm ai./ha , imidacloprid 200 SL and acephate.

3.31
Evaluation of American cotton (*Gossypium hirsutum* L.) genotypes for resistance to Cotton Leaf Curl Disease (CLCuD)

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Cotton is an important commercial crop of global importance. India occupies largest area in the world (12.6 million ha.). However, India ranked second in production (37.4 million bales) with a very low productivity of 537 kg/ha. as compared to world average of 760 kg/ha.(Anonymous, 2015). Among the many limiting factors of low productivity, cotton leaf curl disease (CLCuD) is most crucial in northwestern India. Among the recommended practices to control cotton leaf curl disease (CLCuD), development of cotton leaf curl resistant varieties is long-term approach to cope with this problem and to save the crop from the ravages of cotton leaf curl virus (CLCuV). The main objective of present study thus was to find out resistant genotype, possessing desirable characteristics that can directly be used for commercial cultivation, or it can be used in hybridization programme for the development of new resistant cultivars/ hybrids.

Three hundred seventy five genotypes/varieties were evaluated against cotton leaf curl disease at CCS HAU Cotton Research Station, Sirsa from *kharif* 2011 to 2013 to identify sources of resistance under field conditions where virus source and vector were abundantly present. None of the genotype was found immune/ disease free or highly resistant. However, forty seven genotypes were found resistant, one hundred forty three genotypes expressed moderately resistant reaction and one hundred twenty nine genotypes were found moderately susceptible. Thirty eight were observed susceptible and eighteen were found highly susceptible to CLCuD. The resistant genotypes may be used for variety/ hybrid development or as a donor of resistant genes.

3.32
Effect of weather parameters on development of bacterial blight of cotton

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The field experiment was conducted during 2014-2015 to study the effects of weather parameters on development of bacterial blight of cotton. The study revealed that incidence of bacterial blight was initiated during the first week of September *i.e.* at 36^{th} MW, when the maximum and minimum temperature was 28.8^0C and 22.70^0C respectively with 92.9per cent relative humidity at morning. The disease incidence was increase with increase in temperature. The maximum per cent intensity (20.23per cent) was recorded during 45^{th} MW when the maximum temperature was 33.5^0C and relative humidity was 69per cent. The present findings indicated that maximum temperature and sunshine hours has positive and significant correlation with bacterial blight disease.

3.33
In vitro screening of cotton genotypes for Fusarium wilt resistance using fusaric acid

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In the era of global climate change, biotic stress caused by various pathogens is one of the major constraints in production and productivity of *deshi* cotton all over India. Fusarium wilt of cotton caused by *Fusarium oxysporum* f.sp. *vasinfectum* (FOV) is one of the limiting factor in *deshi* cotton cultivation. Soil born nature of pathogen and recently reported seed transmission of this fungus is posing a challenge to manage the disease. AICRP on cotton, Pune centre is the only centre in India to screen the cotton genotypes developed by cotton breeders against *Fusarium* wilt in seedling resistance test (SRT) and adult plant resistance test (APRT). However, this Pune Technique developed by this centre is labour intensive and time consuming. Also it is very difficult to maintain uniform CFU count and inoculum density in field. Therefore, *in vitro* evaluation of 15 cotton genotypes were carried out in Fusaric acid solution of 0,15,25,30 and 40 ppm concentration as an alternative to SRT and APRT. These cotton genotypes were also tested in SRT and APRT against FOV. In this *in vitro* trial 15 days old seedlings of cotton genotypes *viz.*,, Br.22a/b-566, Br.22a/b-574, F-5/13/08, F-5/13/18, F-5/13/24, F-5/13/26, F-5/13/49, F-5/13/50, F-5/13/53, F-5/13/57, F-5/13/74, F-5/13/75, F-5/13/92, F-5/13/95, F-5/13/101 along with resistnace check AKA 7 and Susceptible check DH 2 were immersed in 20 ml solution of fusaric acid for 20 days in two replications. Seedlings were protected from direct sunlight and incubated at ambient temperature. The observations were recorded everyday for chlorosis, vein clearing and number of days for wilting. Complete wilting of seedlings were observed in all genotypes including resistant and susceptible check within seven days at 25 ppm and above. However, at 15 ppm concentration, wilting of susceptible genotype DH 2 occurred within four days and resistant genotype AKA 7 was observed to be healthy and immune till 20 days. Amongst 15 genotypes, 5 genotypes Br.22a/b-566, Br.22a/b-574, F-5/13/57, F-5/13/95 and F-5/13/101 remained healthy up to 20 days and remaining genotypes were wilted within 4 to 10 days. Result concluded that 15 ppm concentration of fusaric acid can discriminate susceptible and resistant reaction of genotypes by causing wilting and early death of seedling in susceptible cotton genotypes and thus such a short technique can be used for screening of cotton genotypes against Fusarium wilt.

3.34

Seasonal incidence of major sucking leaf hopper (*Amrasca biguttula biguttula*) pest of *Bt* cotton

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The present investigations were conducted during 2011 and 2012 at Departments of Agricultural Entomology, Mahatma Phule Krishi Vidyapeeth, Rahuri to study the resistance of different *Bt* cotton hybrids against jassid, *Amrasca biguttula biguttula* Ishida. Data of *kharif* 2011 and 2012, revealed that seasonal incidence of cotton jassid population started to build up from 30th DAS *i.e.* 3rd week of July average population 1.82 jassid/3 leaves. Then it slowly increased up to 51st DAS *i.e.* 2nd week of August. The jassid population increased gradually during experimental period and ranged between 1.82 and 9.56 jassid/3 leaves. The highest population was observed in 107 DAS *i.e.* 2nd week of 0ctober denoting 9.56 jassid/3 leaves and then the population declined up to 149 DAS *i.e.* 4th week of November indicating 1.76 jassid/3 leaves.

3.35

Chitosan -A natural medium for higher sporulation of *Verticillium lecani* Zimmermann and mortality of white flies *Bemisia tabaci* (Gennadius)

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Whitefly *Bemisia tabaci* (Gennadius) is one of the polyphagus pest causes significant losses on cotton and also on many agricultural and horticultural crops. To manage this pest biopesticides are preferred over chemical pesticides due to non harmful residues, target specific, safe to beneficial organism, eco friendly and cost effective .To evaluate the effectiveness of entomofungal pathogen V*erticillium lecanii (Z*immermann) was tested .For mass culture *V .lecanii* on sabaraud dextrose agar media with chitosan a waste product of prawn scale available in plently in this coastal part was used. Laboratory bio assay of *V .lecanii* was conducted with five doses 2,4,6,8,10ml amounting to 20,40,60,80 and 100per cent of chitoson solution was added to SDA seperately and mixed thoroughly. The medium was autoclaved at 1.15 kg per cm^2 for 15 minand plated four replications were maintained in each dose besides one control with standard medium(without chitosan). This study was conducted with five treatments in randomized block design.. Cultural features of *viz*,biomass, radial growth and spore germination was studied. The 60per cent prawn waste was rated as superior in enhancing the growth parameters and infectivity of *V .lecanii.* Among the different treatments tested, SDA supplemented with 60per cent chitosan resulted significantly enhanced growth of biomass(558.4mg), radial growth (74.9mm), spore germination (79.36%) of *V .lecanii* and caused 65.39per cent mortality of whiteflies.

3.36

Changing scenario of thrips (*Thrips tabaci* Lind.) population on *Bt* cotton in Marathwada region of Maharashtra

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Thrips *(Thrips tabaci* Lindeman) is becoming a major problem on *Bt* cotton in Maharashtra. Due to rapidly changing cropping pattern and environment, changes in pest scenario have become more in recent times. The duration and intensity of thrips infestations vary greatly according to season and geographic location. Keeping this in view scientific survey of thrips incidence on *Bt* cotton was carried out from last five years,

(2009-2010 to 2013-2014) in six major cotton growing districts *viz.,* Parbhani, Hingoli, Nanded, Jalna, Aurangabad and Beed in Marathwada region of Maharashtra under Crop Pest Surveillance and Advisory Project (CROPSAP) by using ICT and total 171 ETL based advisories were issued twice in a week to monitor the pest. During 2009-2010 maximum thrips population (4.85/3 leaves) was recorded in Jalna district followed by Hingoli (4.60/3 leaves) and minimum in Aurangabad (2.10/3 leaves). During 2010-2011, it was highest in Hingoli (5.90/3 leaves) followed by Jalna and Aurangabad (3.95/3 leaves), Beed (3.65/3 leaves) and lowest in Nanded (2.65/3 leaves). Whereas, during 2011-2012 thrips population was maximum in Nanded (4.05/3 leaves) followed by Hingoli (3.85/3 leaves) and minimum in Parbhani (1.35/3 leaves). During 2012-2013, Jalna district is highly infested by thrips (6.00/3 leaves) followed by Beed (3.55/3 leaves), Hingoli (3.50/3 leaves) and Aurangabad with a minimum off 1.40. During 2013-2014, highest thrips incident was recorded in Jalna (6.65/3 leaves) followed by Hingoli (4.65/3 leaves), Parbhani (4.20/3 leaves) and lowest in Nanded (0.45/3 leaves). On the basis of five years mean it was observed that thrips incident was severe in 2010-2011, whereas during 2011-2012 the thrips incidence was comparatively moderate and during years 2009-2010, 2012-2013 and 2013-2014 recorded similar trend of thrips incidence. It was further concluded that Jalna and Hingoli districts were identified as hot spots for thrips.

3.37

Population trends of sucking pests and natural enemies in high density planting system in cotton

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A field experiment was conducted to study the population trends of sucking pests in high density planting system (HDP’s: spacing of 60x10 cm, non *Bt* hybrid Suraj) compared with normal planting system (90x60 cm, non *Bt* hybrid DCH 32) in cotton during the year 2014-2015. Sucking pest’s population *viz.,*, leafhopper, thrips, aphids and mirid bugs population in suraj was 1.02, 3.37, 0.31 and 1.91/m row length which was significantly lower than that of the DCH 32 which recorded 3.38, 5.37, 1.98 and 2.74/meter row length, respectively. Whereas, sucking pests population with respect to whiteflies (Suraj: 0.44/3 leaves and DCH 32: 0.0.39/3 leaves) there was no significant differences was observed. Natural enemies population namely spiders which recorded 1.91, 2.04/plant in Suraj and DCH 32, respectively and were *on par* with each other. Similarly, coccinellids population of 0.98, 1.09/plant of coccinellids were observed in suraj and DCH 32, respectively which did not differ significantly.

3.38

Bioefficacy of *neem* formulation against whitefly, *Bemisia tabaci* Gennadius in *Bt* cotton

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Cotton (*Gossipium* spp) is most important commercial crop in India and plays a vital role in agricultural, industrial, social and monetary affairs of the country. The insect- pest complex of cotton has gone a tremendous change owing to many reasons, *viz.,* adoption of *Bt* cotton, change in economical scenario, use of unrecommended insecticides, mixtures of insecticides and faulty spray technology etc. Pesticides used for crop protection pose serious threat to environment and have undesirable biological effects on animals and human beings. The indiscriminate use of insecticides contributed to the emergence of whitefly, *Bemisia tabaci* Gennadius as major sucking pest of *Bt* cotton. Total reliance on the application of synthetic insecticides for control of whitefly has not achieved the success and induced resistance to several groups of insecticides. This has promoted the necessity for development of new, safer and more effective insecticides that could provide feasible and effective insect pest management. Botanical pesticides are based on ecological principles and are compatible with sustainable crop production. Therefore attempt has been made to use new insecticide derived from plants.

Therefore, an experiment was conducted at Panniwala Mota and Chhatria villages of Sirsa District to test bioefficacy of Nimbecidine (*neem* formulation) in combination with recommended insecticides. Crop was sprayed with different treatments *viz.,* Nimbecidine(0.03%)@1.25 l/ha + imidacloprid 200 SL @ 100ml/ha, Nimbecidine(0.03%)+ thiamethoxam 25WG@100g/ha, imidacloprid 200 SL @ 100 ml/ha and thiamethoxam 25WG @100g/ha at economic threshold level of pest. Spraying of *neem* formulation (nimbecidine 0.03%)@1.25l/ha+imidacloprid@100ml/ha and Nimbecidine(0.03%)+ thiamethoxam@100g/ha recorded 4.4 and 4.3 whitefly adults/leaf at 5 days after spray as compared to 15.2 whitefly adults in control. Population of whitefly adults was recorded 9.9 and 6.8 adults in spraying of imidacloprid(100ml/ha) and thiamethoxam(100g/ha), respectively. In the fields where only imidacloprid(100ml/ha) and thiamethoxam(100gm/ha) was sprayed population of pest remained above economic threshold level. Therefore neem based formulations may be used in IPM strategy in management of whitefly in cotton.

3.39
Evaluation of stem applied neonicotinoids for management of sucking pest complex of *Bt* cotton

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A field experiment was conducted at Experimental farm, Department of Entomology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (M.S.) during *kharif* season of 2013-14 to study the "Evaluation of stem applied neonicotinoids for management of sucking pest complex of *Bt* cotton". The experiment was laid out in a randomized block design with 12 treatments each replicated thrice. The experimental unit was of 5.4m x 6m size. The treatment comprised of four chemical in which they used at different concentration, imidacloprid @ 1:10 dilution, imidacloprid @ 1:30 dilution, imidacloprid @ 1:50 dilution, thiomethoxam @ 1:10 dilution, thiomethoxam @ 1:30 dilution, thiomethoxam @ 1:50 dilution acetamiprid @ 1:10 dilution, acetamiprid @ 1:30 dilution, acetamiprid @ 1:50 dilution, clothiniadin @ 1:10 dilution, clothiniadin @ 1:30 dilution, imidacloprid @ 1:50 dilution and untreated control.
The treatment with stem application of clothiniadin @ 1:10 dilution and imidacloprid @ 1:10 dilution at 30 and 45 DAY recorded highest yield of seed cotton, followed by thiomethoxam @ 1:30 dilution, clothiniadin @ 1:30 dilution and acetamiprid @ 1:10 dilution. The treatment with acetamiprid @ 1:50 dilution and thiomethoxam @ 1:50 recorded lower yield of seed cotton amongst insecticidal treatments. It was observed that the treatment with imidacloprid @ 1:50 dilution and acetamiprid @ 1:50 dilution gave higher cost benefit ratio and were the most economical treatments. The treatments in order of their merit were imidacloprid @ 1:30 dilution, acetamiprid @ 1:30 dilution, thiomethoxam @ 1:50 dilution and imidacloprid @ 1:10 dilution.

3.40
Record of Mealybug complex in *Bt* cotton

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Commercialization of *Bt* cotton led to a change in pest scenario, which resulted in the emergence of minor pests into a major pest occurred on cotton at Perambalur district of Tamil Nadu. It has attained serious pest status in cotton growing areas of Perambalur since 2009. During 2010-2014 a survey was conducted on the occurrence of mealybug complex in cotton at Perambalur district. A total of seven mealybug species belonging to Pseudococcidae and Monophlebidae families of Hemiptera order were recorded. These mealybug species were spherical mealybug *Nipaecoccus viridis* (Newstead), striped mealybug *Ferrisia virgata* (Cockerell), Pink hibiscus mealybug *Maconellicoccus hirsutus* (Green), mango mealybug *Rastrococcus iceryoides* (Green) (Pseudococcidae) and ber mealybug *Perissopneumon tamarindus* (Green) (Monophlebidae). Cotton mealybug *Phenacoccus solenopsis* (Tinsley) *and* papaya mealybug, *Paracoccus marginatus (*Williams and Granara de Willink) was found as major pests of cotton. Cotton mealybug *P. solenopsis* and papaya mealybug, *P.marginatus* was found to most widely distributed mealy bug species in cotton and other alternate host of Tamil Nadu

3.41
Stem application in cotton : reasons for non adoption

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Cotton is an important commercial crop grown in India, which is attacked by a number of pests. Sucking pests cause considerable damage in the initial days and bollworms in the latter days of the crop growth. Major sucking pests in cotton are aphids, hoppers, jassids, whiteflies and thrips. Of these the damage caused by the aphids, hoppers and jassids is more during the initial days. To control sucking pests in cotton, scientists of RARS, Lam have developed a method called stem application, which is cost effective and eco-friendly. By this method sucking pests could be controlled by the application of systemic insecticides at 20, 40, 60 days after sowing. The technique is well suited for areas where water scarcity is more. It does not need any costly equipment and involves no skill. Saving on plant protection measures and ease of application are the merits of this technology. With the introduction of *Bt* cotton the boll worm damage become minor and sucking complex has become major and adoption of stem application become more important. With this background study conducted Guntur district of Andhra Pradesh indicated that among the insecticides used on cotton 90 per cent and among the total pesticides 69.99 per cent utilised towards controlling sucking complex. But, the adoption is negligible. It was found that among the perceived constraints in adoption of stem application, 'laboriousness' ranked first followed by 'constant vigilance required on employed labour' as the 2nd most perceived constraint.

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