CROP IMPROVEMENT AND BIOTECHNOLOGY

POSTER PRESENTATIONS

Crop Improvement

1.1
Fibre quality status in *Gossypium arboreum* germplasm

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Diploid cottons are commonly known as *desi* cottons. The *desi* cottons are inherently resistant to sucking pests and cotton leaf curl virus diseases. In the present study 119 *G. arboreum* germplasm lines were evaluated for four important fibre characters *i.e.* 2.5 per cent span length, uniformity ratio, micronaire value and fibre strength. The lint samples were analyzed for these fibre quality traits at Regional CIRCOT Lab., Sirsa and superior lines were identified. The 2.5 per cent span length ranged from 15.5 (AC 3376) to 26.7 mm (FFS) 44 with mean value of 21.1 mm. Out of 119 germplasm lines, 42 lines had short fibre, 58 falls in medium fibre group and medium long fibre category had 19 lines. No *arboreum* germpasm line had long and extra long 2.5 per cent span length of fibre. The uniformity ratio (%) ranged from 48 to 53 with mean value of 52. Only five lines had the uniformity ratio below than 50. The micronaire values ranged from 5.0 to more than seven. Fifty genotypes had micronaire value more than seven whereas; 46 genotypes fall in the range of 6.0 to 7.0 and only 23 germplasm lines had below than 6. The fibre strength (tenacity) ranged from 12.9 to 20.2 g/tex with a mean value of 16.2 g/tex indicated low fibre strength in the present germplasm stock. The above mentioned genetic stock lines superior for differentfibre quality parameters may be utilized for development of varieties / hybrids with better fibre quality.

1.2
Stability analysis of seed cotton yield and other quantitative traits in American cotton

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Twelve pure breeding genotypes of American cotton were tested to determine their stability for seed cotton yield in four distinct environments. Mean sum of squares due to genotype and environment differed significantly for all the traits *viz.*, seed cotton yield, number of bolls, boll weight and ginning percentage. Significant E+ (G x E) interaction showed differential response of these genotypes under different environments. Significant (G x E) linear interaction when tested against pooled error indicated that the predication of performance of these characters in different environment is possible. Pooled deviations were

significant for all traits indicating that genotypes differed considerably with respect to the stability for these characters. The genotype AKH 0205 showed stable performance for seed cotton yield considering all stability parameters with high mean values. This genotype ranked second in yield performance and exhibited least S^2di value and bi nearer to unity. The genotype AKH 9916 showed average stability with average seed cotton yield. The genotype AKH 2007-5, AKH 28-2-2 and AKH 2006-4 were found stable for number of bolls, boll weight and ginning percentage, respectively.

1.3
Genotype x environment interactions for seed cotton yield and component characters in *desi* cotton (*Gossypium arboreum* L)

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Stability performance of 14 *arboreum* cotton genotypes was tested in three different environments of Vidarbha region. Mean sum of squares due to genotype and genotype x environment (G x E) were significant for all the traits except number of bolls indicating sufficient genetic variability among the genotypes. Significant E+ (G x E) and environment mean sum of squares indicated differential response of these genotypes under varing environments. Likewise, significant (G x E) interaction for all the traits except number of bolls revealed the interplay of genotypes with environments. Simultaneous consideration of all the parameters of stability indicated that the genotype AKA 9620 and AKA 06-05 were stable for seed cotton yield. The genotype AKA 9620 also showed stable performance for number of bolls with high mean value. For boll weight and ginning percentage, the genotype AKA 9703 and AKA 9602 showed stable performance with high mean over the locations.

1.4
Stability performance of newly developed GMS based *desi* cotton hybrids

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Eight GMS based *arboreum* cotton hybrids were tested for their stability performance along with two released *desi* cotton hybrids and a variety over three different locations of Vidarbha region. Analysis of variance for stability revealed significant genotype and environment mean sum of squares indicating sufficient genetic variability and difference in environments. Significant E+ (G x E) and (G x E) interactions indicated differential response of genotypes under different environments. Significant (G x E) linear interaction when tested against pooled error revealed the possibilities of predication of performance of these genotypes over the environments. Estimates of mean, regression coefficient and deviation from regression exhibited that three hybrids *viz.*, AKDH 92, AKDH 91 and AKDH 93 showed stable performance for seed cotton yield over the locations with high mean performance. The hybrid AKDH 92 also exhibited stable performance for number of bolls/plant and ginning percentage with high mean values.

1.5
Variability and correlation analysis in intra *hirsutum Bt* cotton hybrids

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Variability and correlations were studied in 24 *Bt* cotton hybrids of *Gossypium hirsutum* of diverse origin. Significant differences among the hybrids for all the seven characters were observed. The components *viz.*, phenotypic ($ó^2p$), genotypic ($ó^2g$) and environmental ($ó^2e$) variances were used for estimation of phenotypic and genotypic coefficient of variations. The phenotypic coefficient of variation (PCV), which measures the total variation, was found to be greater than genotypic coefficient of variation (GCV). Moderate to high estimates of heritability along with high genetic advance were noticed for lint index, seed index, bolls/ plant, seed cotton yield/plot and lint yield, indicating the presence of additive gene action in the expression of these traits. Genotypic and phenotypic correlation showed that seed cotton yield/plot had significant positive association with ginning outturn (%) at genotypic level. while lint index, seed index and bolls/ plant showed significant positive association with seed cotton yield at genotypic and phenotypic levels. The positive significant correlation was observed for both the characters *viz.,* seed index (g) and lint index (g) bolls/plant at genotypic and phenotypic levels. Thus, for increasing seed cotton yield in cotton, due emphasis should be given to ginning outturn (%), lint index (g), seed index (g) and bolls/plant. All the characters which had high heritability and highly significant positive association with seed cotton yield can be increased through selection in cotton.

1.6
Heterosis and combining ability for yield and its components in *deshi* cotton (*Gossypium arboreum* L)

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Investigation was carried out during 2009-2010 at Oilseeds Research Station, MPKV, Jalgaon to study the heterosis and combining ability and yield related traits in *G. arboreum* by using 7x7 half diallel mating design. The analysis of variance revealed significant differences among genotypes for all characters. The analysis of variance for combining ability revealed that the variance due to general combining ability (GCA) was lower than specific combining ability (SCA) indicating non additive type of gene action was predominant for all characters. The parent JLA 794 was good general combiner for seed cotton yield. The parent Hegha 46 found good general combiner for number of bolls, average boll weight and lint yield (Kg/ha). Cross Hegha 46 x MDL 2643 showed highest heterobeltiosis, significant SCA and involved one good general combiner parent for seed cotton yield.

1.7
Combining ability studies for yield and other traits in upland cotton (*Gossypium hirsutum* L)

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Present study was undertaken to determine the inherent potential of parental stocks to produce high yielding hybrids. For this purpose, 64 upland cotton hybrids were developed crossing 16 lines with 4 testers in a line x tester mating design during *kharif* 2010. These hybrids excluding parents were evaluated during *kharif*, 2011 at Cotton Research Station, CCS HAU, Sirsa. The combining ability analysis revealed that both additive and non additive variances were present in the expression of all the characters with the former playing major role for majority of the characters. Highest *sca* effects for seed cotton yield were recorded for hybrids H 1117 x Sahane and H1098 x LH 1995. For yield contributing characters boll number and boll weight H1098 x LH 1995 and H 1226 x LH 1995 respectively, were best specific combinations. The study of *gca* effects revealed that male parent H 655 C was the best general combiner for boll number a potent yield component and number of monopods and also possessed high *gca* for seed cotton yield. However, best general combiner for seed cotton yield was EC 543243. Male parent JP 8 and P 12 were best general combiners for another important yield component, boll weight and seed index respectively. For plant height and number of sympods male parent PK 54 was the best general combiner. Similarly, for quality character, ginning outturn male parents MC 86 and H 841 showed highest *gca* effects. The respective best combiners for various traits could be used for improvement in that trait. Considering the economic importance of various characters H 655C, EC 543243. JP 8 and HS 30 among the males and HS 182 and H 1117 among the females may be used in future breeding programmes.

1.8
Improvement for seed cotton yield and its component traits through heterosis breeding in *Gossypium hirsutum* L

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A study was made in *Gossypium hirsutum* to estimate the magnitude of heterosis among different cross combinations for yield and its component traits. For this purpose, sixty four hybrids were developed during *kharif* 2010 in a line x tester mating design and evaluated along with check (HHH 223) for yield traits during *kharif* 2011 at CRS, CCS HAU, Sirsa. The analysis of variance indicated that the mean squares of genotypes for all the characters investigated were significantly different, indicating the presence of variability among hybrids and their parents. Studies revealed that the maximum heterosis for seed cotton yield were observed in cross combination H1117 x EC543343 (47.87%) followed by cross H1117 x Sahane (42.61%). Range of heterosis was -25.31 to 47.87 per cent for seed cotton yield, -13.32 to 79.90 per cent for bolls/plant, -9.56 to 38.44 per cent for boll weight, -13.24 to 37.90 per cent for seed index, -7.01 to 6.46 per cent for ginning

out turn, -84.90 to 126.44 per cent for monopods per plant, -18.76 to 27.02 per cent for sympods per plant and -3.53 to 25.19 per cent for plant height. Hybrids H 1117 x H655C and HS182 x HS 30 showed heterosis for all the characters studied. All the hybrids were moderately to highly resistant to CLCuD and other diseases. On the basis of results, four lines namely H655 C, EC543342, HS 30, H841 and testers H1117 and HS 182 were identified promising as these were involved either one or both the parents in the crosses that showed significantly positive heterosis for seed cotton yield. The study also reveals good scope for commercial exploitation of heterosis as well as genetic Improvement for seed cotton yield and its component traits through isolation of pure lines among the progenies of other heterotic F1 hybrids.

1.9
Development of high yielding long linted good fibre quality early maturing *Gossypium hirsutum* genotypes for north zone conditions

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Long linted good fibre quality *G. hirsutum* genotypes from south and central zone are usually poor yielder and late maturing under north zone conditions. To develop high yielding long linted good fibre quality early maturing *G.hirsutim* genotypes for north zone conditions six long linted genotypes (2.5% span length about 30mm) from CICR,RS, Coimabatore *viz*; M.M 03-22-1-2, M.M 03-27-5-1-5, M.M 03-39-2-5 , M.M 03-40—2-4-1, M.M 03-27-5-1-8 , M.M 03-39-2-5 were used in crossing programme . These genotypes were late maturing and poor yielder. These lines were crossed with good yielder high fibre strength (about 25g/tex) Sirsa cultures , CSH 3114 , CSH 3119 and CSH 3047. In the advanced generation cross CSH-3114xMM-03-27-5-1-5 gave fibre strength more than 25g/tex and fibre length>31 mm. Early maturing and good yielder advanced generation material of crosses CSH 3119xMM 03-3-22-1-2 , CSH 3119x MM03-27-5-8 , MM03-22-1-2xCSH-3047 and MM03-39-2-5xCSH-3047 with fibre length around 30mm and fibre strength around 23g/tex have been selected from the material in the crossing programme for further use.

1.10
Promising American cotton (*Gossypium hirsutum*) germplasm for ginning outturn with yield

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Cotton is the most important commercial crop of the country which is grown in around 15 lakh ha in north zone. Cotton germplasm is the basic source for improvement of yield and fibre properties and biotic and abiotic resistance. Among the various traits which contribute for lint yield, the ginning outturn is a most important parameter. In all the varieties/hybrids released for cultivation under north zone the ginning outturn is around 35-38 per cent which is a reason for lower lint yield and need immediate attention. During 2011-2012, 3954 geographically and diverse lines from gene pool of G. *hirsutum* cotton maintained at

Central Institute for Cotton Research, Nagpur were evaluated under north zone at CICR, Regional Station Sirsa and data on ginning outturn recorded. The crop of these accessions was raised adopting recommended agronomic and plant protection measures. A wide range of variability for ginning outturn from 21.7 to 44.0 per cent was observed among the accesssions. Among the evaluated lines more than 100 lines were observed with ginning outturn higher than 40 per cent and among these, the higher yield/plant was also noted in acessions SA 1456 (100.2g), IC 359275 (104.5 g), IC 359132 (105.6 g), IC-358738 (108.1 g), IC-359317 (114.6 g), IC 359429 (128.4 g), IC 359348 128.4 g) and IC 359383 (149.2 g) with ginning outturn above 42.3 percent. The CLCuD is the serious threat for north zone and among the superior line for ginning outturn, accession IC 358988, SA 1332, IC 359725, lCO359737, IC 359132, IC 359835 and SA 1394 were observed tolerant to CLCuD along with yield potential of more than 100 g/plant. Based on the study the superior genotypes for ginning outturn along with higher yield potential and resistance to CLCuD are available which can be successfully used for replacement of existing cultivars with lower ginning outturn as well as their utilization in the crop Improvement programmes.

1.11
Heterosis for seed cotton yield and yield contributing characters of *Gossypium hirsutum* L in upland cotton

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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. Fifty four hybrids (Six females and nine males) were developed during *kharif* 2006. These hybrids along with parents and three checks PHH 316, NHH 44 and Bunny were planted in *kharif* 2007 at three different 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 %) and Bunny (75.33 %). The bolls/ plant, boll weight and ginning percentage. The positive significant heterosis was recorded by the cross KH 121 x PH 348 over better parent (25 %), over checks PHH 316 (25 %), NHH 44 (8.11 %) and over Bunny (4.76 %) for boll weight. In respect of fibre parameters, hybrid KH 120 x Cocker (28.78%) had recorded maximum positive significant heterosis over better parent. However, the cross KH 120 x PH 1024 had exhibited positive significant heterosis over PHH 316 (12.67 %) and over NHH44 (23.18%) for 2.5 per cent span length. Hybrid KH 120 x L 761 had recorded highest positive significant heterosis over better parent (48.91 %) and checks PHH 316 (12.45 %), NHH 44 (34.14 %) and Bunny (0.50%) for fibre length.

1.12
Combining ability studies for seed cotton yield and its contributing traits in *Gossypium hirsutum* L cotton

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Development of new varieties with higher yield and better quality parameter is the prime objective of cotton breeders. In the present investigation aims to estimate general combining ability and specific combining ability for seed cotton yield and quality traits. For estimating the combining ability effects four robust genotypes were crossed with ten tester in line x tester fashion and resulting forty hybrids were raised during *kharif* 2010 in a randomized block design with three replications. Analysis of variance for combining ability revealed that predominance of non- additive gene action for all the characters under study except fibre strength and elongation percentage. For seed cotton yield per plant and its contributing traits GSHV 112, 76 IH 20 and GSHV 152 were observed good general combiner. On the basis of *sca* effects, the cross combinations G.Cot.16 x G.Cot.20, GSHV 152 x BC 68-2, G. Cot.10 x GISV 257, G. Cot.10 x GSHV 112, G.Cot.16 x GISV 218 and GSHV 158 x GBHV 148 exhibited highest magnitude of positive significant *sca* effects for seed cotton yield and its components.

1.13
Comparative performance of GMS based *Gossypium arboreum* cotton hybrids under irrigated and rainfed conditions

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The present investigation was carried out using line x tester analysis consisting of seven genetic male sterile (GMS) lines as female parents and six contrasting *arboreum* strains as male parents at Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri for irrigated conditions and at Agricultural Research Station, Jalgaon for rainfed conditions, to have information on extent of heterosis for seed cotton yield and yield components in Asiatic cotton. The experiment was laid out in randomized block design (RBD) with three replications in both the locations. The analysis of variance revealed that the parents and hybrids differed significantly for all the characters under study indicating presence of considerable genetic variability between the genotypes. The results revealed that the magnitude of standard heterosis was high for seed cotton yield, boll weight and ginning percentage. Three GMS based hybrids *viz.*, RHAH 1040, RHAH 1022, RHAH 1010 exhibited significant and positive standard heterosis for seed cotton yield over *G. arboreum* checks Suvarna and JLA 794. For fibre quality traits crosses *viz.*, RHAH 1041, RHAH 1034 RHAH 1009 and RHAH 1007 were found promising.

1.14
Bt cotton in Rajasthan

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Until today more then 1050 *Bt* cotton hybrids have been identified by GEAC for commercially cultivation in India. Hybrids have cry 1 Ac (event Mon 531 bollgard I) gene, Bollgard II which carry two genes (cry 1 Ac cry 2 Ab Mon 15985 event) cry 1 Ac (event 1) developed by IIT Khargpur. Six hybrids have fusion gene of China (Cry 1 Ab + Cry 1 Ac event GFM event). In addition, the following genes have also been approved for transgenic research but so far have not been commercialized. Cry 1 Ac of Cal gene ,vip 3 A of Syngenta, Cry 1 Ac and Cry 1 F of Dow Agro Sciences, cry 1 Ac of NRCPB and UAS Dharwad, and cry 1 c and CPTi of Mahyco and Nath Seeds. More than hundred *Bt* cotton hybrids have been recommended by GEAC for commercial cultivation in north India. However, on the basis of performance in search trials conducted during *kharif* 2007 and 2008 at Agricultural Research Station, Sriganganagar six hybrids mainly RCH 134 *Bt*, RCH 314 *Bt*, MRCH 6025 *Bt*, MRCH 6304 *Bt*, JKCH 1947 and NECH 6 *Bt* hybrids gave significantly higher seed cotton yield over highest *Bt* check (*Bt*). These above mentioned Bt hybrids have been recommended by Zonal Research Extension Advisory Committee of SKRAU Agricultural Research Station, Sriganganagar for cultivation in Rajasthan. As a consequence of rapid adoption of *Bt* cotton and improved crop production and protection technologies, the area of *Bt* cotton has increased up to 80 per cent in Rajasthan, which has increased the productivity of cotton in the State. However, due to high incidence of leaf curl virus disease in Bt cotton hybrids the crop had a setback also. The *Bt* cotton reduces the need of chemical sprays, labour, environment pollution and resulted in high yields.

1.15
Combining ability analysis in cotton (*Gossypium hirsutum* L) for yield and fibre characters

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Combining ability analysis for seed cotton yield and fibre characters were studied in a set of half diallel crosses involving six cotton genotypes *viz.*,241-4-2, G cot 100, RFS 3438, 65-2(s)-3, Hyps 152 and Suvin. Both additive and non additive gene actions were important in the inheritance of most of the traits like yield ,harvest index ,boll weight, seed index, lint index, GOT, fibre length, fibre strength and node number. Predominance of additive gene action for inheritance of uniformity ratio and non additive gene action for number of bolls in the inheritance of traits. Genotypes Hyps 152 and 241-4-2 exhibited significant positive *gca* effects for yield/plant, boll weight, and harvest index. Suvin and Hyps 152 showed significant positive *gca* effects for seed index. Whereas Hyps 152 showed significant positive *gca* effects for boll weight, yield, harvet index, seed index, lint index and fibre strength.RFS 3438, 65-2(s)-3 and G. cot 100 exhibited significant

positive *gca* effects for GOT. Suvin is the best general combiner for fibre length and fibre strength. Crosses 241-4-2 x Hyps 152, 241-4-2 x RFS 3438 ,G cot 100 x 65-2(s)-3 and 65-2(s)-3 x Hyps 152 exhibited significant positive *sca* effects for seed cotton yield. These crosses may directly be used for exploitation of hybrid vigour by adopting heterosis breeding for commercial exploitation of hybrid vigour.

1.16
Biometrical traits based genetic diversity of cotton (*Gossypium arboreum* L) germplasm lines

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The concept of genetic distance has been of vital utility in many contexts and more so in differentiating well defined populations. Quantification of genetic diversity existing within and between groups of *Gossypium arboreum* L. germplasm is important and particularly useful in proper choice of parents for realizing higher heterosis and obtaining useful recombinants. An investigation was undertaken with 150 *Gossypium arboreum* L. genotypes during late *kharif* 2011 to determine the genetic variation within cotton populations collected from different part of India. Genetic divergence study using Mahalanobis D^2 statistic grouped 150 genotypes into 34 clusters. Cluster XXXII was the largest comprising of 63 genotypes followed by cluster XXXIV and XXXIII with 17 and 7 genotypes respectively, whereas all other clusters had only two genotypes each. Intra cluster distance was highest in the cluster XXXIII, whereas, minimum in cluster II. The genotypes included are found to be very diverse in nature as they showed maximum inter cluster distance (D^2) between the clusters XXXIII and XXXIV and the minimum D^2 value was recorded between the clusters III and V. With respect to the contribution of each trait to the total genetic divergence, the biometrical trait by seed cotton yield contributed maximum followed, boll weight (g), bolls/plant, plant height, monopodial branches/plant and number of sympodial branches/plants.

1.17
Genetic diversity of cotton (*Gossypium hirsutum* L) germplasm lines based on morphological traits

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Existence of genetic diversity is an essential requirement for successful hybridization programme. In order to take the programme of development of hybrid cotton successfully, choice of suitable parent through careful and critical evaluation is of paramount importance. This is because *per se* performance of a parent is not always true indicator of its potential in hybrid combination. There are several critical methods by which a breeder can choose suitable parents for successful hybridization, of which an important one is the estimates of genetic diversity among parents. Analysis of genetic relationships among and within crop species is a prerequisite to any viable genetic improvement and for development of superior and heterotic

hybrids in cotton, it is essential to evaluate large number of available germplasm . An investigation was undertaken with 160 *G. hirsutum* genotypes during *kharif* 2011 to determine the genetic variation within cotton populations collected from different part of India. Genetic divergence study using Mahalanobis D^2 statistic grouped 160 genotypes into 15 clusters. Cluster XV was the largest comprising of 87 genotypes followed by cluster I with 47 genotypes, and all other clusters had only two genotypes each. Intra cluster distance was highest in the cluster XV, whereas, minimum in cluster II. The genotypes included are found to be very diverse in nature as they showed maximum inter cluster distance (D^2) between the clusters I and VII, the minimum D^2 value was between the clusters II and VI. With respect to the contribution of each trait to the total genetic divergence, the biometrical trait boll weight (g) contributed maximum followed by seed cotton yield, GOT (%), bolls/plant, plant height, monopodial branches/plant and sympodial branches/ plants.

1.18
Studies of genetic parameters for seed cotton yield and its contributing characters in *Bt* cotton hybrids

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Eighty seven *Bt* cotton hybrids were studied to observe genetic variability, heritability and genetic advance for seed cotton yield and its contributing characters. The analysis of variance revealed that the sufficient variability was present in the material for all the characters. The value of phenotypic coefficient of variation (PCV) is greater than genotypic coefficient of variation (GCV); it means that the apparent variation is not only due to genotypes but also due to influence of environment. Seed cotton yield/plant provided high estimates of genotypic and phenotypic coefficients of variation coupled with high heritability and high expected genetic gain as a per cent of mean, which provides better scope for advancement through direct selection. Similar results were also observed for boll weight. Hence, for improvement in seed cotton yield due weight age should be given to monopods.

1.19
Genetic diversity in *Bt* cotton hybrids

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Cotton is one of the most important commercial crop playing a key role in the economy of the nation. The experimental material for present investigation comprised of 87 *Bt* hybrids of *Gossypium hirsutum* of diverse origin, grown in randomized block design with two replications of a four row of 6 m length at research area of Department of Plant Breeding, CCS Haryana Agricultural University, Hisar during *kharif*,

2011. The spacing between rows was 67.5 cm and plants in a row were kept 60cm apart. Recommended agronomic and plant protection measures were adopted. On the basis of D^2 values, eighty seven *Bt* cotton hybrids were grouped into thirteen clusters containing three to thirteen hybrids. These clusters consisted of genotypes with different geographical origins and indicated no correlation between genetic divergence and geographical divergence. The hybrids of Cluster XI showed maximum genetic divergence with Cluster II followed by Cluster X with cluster III. The genotypes belonging to cluster XI and cluster II may be selected for hybridization for generating genetic variability. Cluster X having seven hybrids was found to be best performing for agronomic characters followed by cluster V with five hybrids and cluster II with five hybrids. Thus to generate desirable genetic variability the crossing between cluster X, V and II hybrids would be useful. It is suggested that hybridization among the genotypes of above said clusters would produce segregants for more than one economic character which can serve as parents.

1.20
Study of apomictic behaviour in cotton genotypes by different methods

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Study of apomictic phenomenon in IS 244-4-2, IS 244-4-3 and IS-181-7-1 cotton derivatives lines was done during 2008-2009 and 2009-2010 *kharif* seasons at Cotton Research Station, Nanded. Testing was done for apomictic phenomenon by methods *viz.* 1. Emasculation followed by selfing of the same flower 2. Complete removal of stigma and style 3.Crossing with dominant marker genotype [(i) Okra type leaf (PH 330) and (ii) Pigmented staminal column (1044 (a)] and 4.Crossing with CMS A line (BN 1). Total 28 lines were tested with emasculation and selfing (EMS) and stigma style cut (SSC) during 2009-2010 season for apomictic behaviour. In case of IS-244-4-2 line, the two genotypes IS 244-4-2-19 and IS 244-4-2-27-7 showed 0.51 to 1.08 percent boll set by emasculation and selfing (EMS) method. No boll set with stigma style cut method was observed, though the boll formation in initial stage and boll shedding after 10-15 days were noticed. These two genotypes also formed boll setting with very low frequency by emasculation and selfing (EMS) method during year 2008-2009 season. The derivatives of line IS 244-4-3 showed Similar results regarding boll setting with both method of conformation. The only one genotype IS 244-4-3-5-1-1-1 showed boll setting percentage of 2.08 and 4.21 per cent with EMS and SSC methods respectively. All the genotypes of line IS 181-7-1 did not give response for boll setting and retention with both the method of conformation. Testing by crossing with Dominant marker genotype [(i) Okra leaf type (PH 330) and (ii) Pigmented Staminal Column [1044 (a)] and crossing with CMS A line [BN-1] was carried out during 2008-09 *kharif* season. Out of 21 crosses with dominant marker genotype, Okra leaf type (PH 330) , only six crosses, IS 244-4-3-8 x PH 330 (25.53 %), IS 244-4-3-16-2-1 x PH 330 (7.69%), IS 181-7-1-19 x PH-330 (7.14%), IS 181-7-1-89-2-1 x PH 330-1 (78.57%), IS 244-4-2-19-1-1-2 x PH 330 (100 %) and IS 244-4-2-27 x PH 330-1 (5.88 %) showed variable degree of normal leaf type. Out of 13 crosses (genotype under testing x 1044 a) tested by pigmented staminal column, eight genotypes showed non pigmented nature with a range of 11.76 per cent to 50.00 per cent. Twenty seven crosses were made by using test genotypes as male parent and cms A line (BN-1) as female parent. Selfing was done in the above crosses and observations on boll setting were recorded. Boll setting was observed in only one cross BN-1 x IS- 244-4-3-34-1-1-1. In case of other crosses, boll setting was observed after selfing but shedding of bolls was noted after boll retention upto 10-15 days. Further embryological and cytological studies of these lines are required for confirmation of nature of apomictic phenomenon.

1.21
Genetic divergence for morpho physiological traits influencing seed cotton yield in upland cotton

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Cotton (*Gossypium spp.)* popularly called "White Gold" is the most important renewable natural fibre crop of global importance and is the mainstay of India's economy. A thorough understanding on variability, heritability and genetic advance of physiological and morphological characters besides yield related metric traits, can be used strategically in designing crosses and to fix up a selection criteria not only to improve yield but also the plasticity and helping to construct a model plant type for each of the target environments. In this context the present study assumes importance. Among the 21 attributes studied in a set of 40 genotypes that were obtained from all over India and evaluated during *kharif* 2010 at Agricultural College Farm, Bapatla, recorded moderate to high variability and high heritability coupled with high genetic advance as per cent of mean for traits *viz.,* plant height, sympodia/plant, boll weight, ginning outturn, CGR at 60-120 days, LAI at 120 DAS and seed cotton yield plant indicating the predominance of additive gene action and hence, direct phenotypic selection may be useful with respect to these traits. Correlation and path analysis indicated that bolls/plant, boll weight, lint index, ginning outturn and harvest index had positive significant and positive direct effect with seed cotton yield plant indicating the use of these attributes in selection to evolve high yielding varieties of upland cotton. The results of multivariate analysis indicated the presence of considerable genetic divergence among the 40 genotypes studied. By Mahalanobis' D^2 statistic, it could be inferred that CGR at 60-120 days, bolls/plant, boll weight, LAI at 120 DAS and seed cotton yield plant contributed maximum towards genetic divergence. The genotypes TCH 1218, NA 1584, GSHY 01/1338, and CSH 17 showed maximum inter cluster distance in Mahalanobis' D^2 analysis, principal component analysis and cluster analysis. So these genotypes can be exploited for the development of heterotic hybrids in future breeding programmes.

1.22
Evaluation of American cotton (*Gossypium hirsutum*) genotypes for their performance in South Haryana

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A field experiment was conducted at CCS HAU, Regional Research Station, Bawal, Haryana during *kharif* 2011-2012 to evaluate the performance of 41 genotypes (including checks) of American cotton for seed cotton yield and other parameters. The seed materials for the experiment were received from Project Coordinator, All India Coordinated Cotton Improvement project. The southern part of Haryana comprises of district Rewari, Mohindergarh and Gurgaon, where the main crops during *kharif* season are pearlmillet and

cluster bean. The soils of these districts are light to medium textured and cotton is growing in few hectares only. The observations were recorded on plant population, number of days taken to first flower, bolls/ plants, boll weight and seed cotton yield. The significant differences among genotypes were observed. The genotype CA-105 (35.80q/ha) ranked first in terms of seed cotton yield followed by CSH 3080 (34.16 q/ha) and CSH 2838 (33.33 q/ha).

1.23
Correlation and path analysis for seed cotton yield improvement in cotton (*Gossypium hirsutum* L)

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The correlation and path coefficient analysis in upland cotton was carried out during summer 2011. The experimental material comprised of sixty eight genotypes. The correlation study revealed that seed cotton yield was significantly and positively correlated with seven traits namely bolls/plant (0.501), number of monopodial branches/plant (o.446), plant height (0.421), seed index (0.645) and boll weight (0.044) and lint index (0.066). Ginning out turn and days to first flower showed significant negative correlation with seed cotton yield. Hence, selection for these characters will help in selecting genotypes with high seed cotton yield/plant. The component of residual effect of path analysis in yield and fibre quality traits was 0.069. The lower residual effect indicated that the characters chosen for path analysis were adequate and appropriate. From this study, very high positive direct effect was observed for bolls/plant (1.030) and boll weight (0.411) followed by monopodial branches/plant (0.055), ginning percentage (0.040), seed index (0.029) and days to first flower (0.005) on seed cotton yield. The high indirect positive effect on seed cotton yield/ plant was noticed by plant height through number of bolls per plant (0.609) followed by days to first flower with boll weight (0.114) and monopods with bolls/plants (0.893).

1.24
Heterotic studies for yield and its component traits in upland cotton (*Gossypium hirsutum L)*

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The present investigation was undertaken to estimate standard heterosis with the objective of exploring possibilities of its commercial utilization. The material for the present study comprised of 42 hybrids developed on three male lines (testers) using 14 female parents (lines) in a line x tester mating design along with their 17 parents (14 lines and 3 testers) and one standard check (HHH 223). The experimental material was grown at Research Area of Deptartment of Plant Breeding, CCS HAU, Hisar, in randomized

block design with three replications. Observations were recorded for characters namely, plant height, boll number, boll weight, number of monopods, ginning outturn, seed index and seed cotton yield/plant. The standard heterosis was calculated over check hybrid HHH 223. Marked economic heterosis was observed for most of the characters studied. Among all the hybrids studied, cross combination RS 875 x HS 88 exhibited heterotic effects (49.46%) for seed cotton yield/plant followed by Machha early x HS 6 (40.23%), Tidewater 4 x HS 88 (36.28%) and HS 223 x HS 88 (35.93%). The magnitude of heterosis is reasonably high warranting their testing for commercial exploitation. Significant positive heterosis for boll number was also recorded in most of the promising hybrids.

1.25
Stability analysis for seed cotton yield and its component traits in *Gossypium arboreum* L

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The present study was undertaken to estimate the stability parameters of promising *arboreum* cotton genotypes and identification of most stable genotype in cotton (*Gossypium arboreum* L.). The material studied consisted of twenty genotypes which includes two released variety having considerable amount of genetic diversity. All these genotypes were grown at two locations *viz.*, Hisar and Sirsa. The crop at Hisar and Sirsa were sown on two different dates thereby creating a total of four environments. All the genotypes were grown in randomized block design with three replications in each environment. Observations were recorded for seed cotton yield and its component traits. The environmental indices revealed that 'E_1' was best for most of the characters followed by E_2. The joint regression analysis indicated that both linear and non linear components contributed to total G x E for all the characters. The estimation of stability parameters for individual genotypes revealed that among the promising genotypes only one genotype HD 468 has been found stable for all the characters studied. On the basis of yield, seven genotypes namely HD 468, HD 473, HD 424, HD 467, HD 123, HD 451 and HD 465 were found desirable with high mean value and non significant S^{-2}di value and significant 'bi' values except HD 468, HD 451 which were devoid of both 'bi' and S^{-2} di values. These nine strain should be extensively tested for their release as a commercial variety.

1.26
Studies on genetic divergence in upland cotton (*Gossypium hirsutum* L*)*

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Genetic divergence in 68 upland cotton (*G. hirsutum* L.) genotypes was studied for different yield contributing characters. The distribution of genotypes indicated that the geographical diversity and genetic diversity were not related and there are forces other than geographical separation which are responsible for diversity such as natural and artificial selection, exchange of breeding material, genetic drift and environmental variation. The intra and inter cluster distances revealed that inter cluster distance values were greater than intra cluster distance values. The intra cluster distance in cluster V was nil as this cluster consisted of only one genotype. The high intra cluster distance in cluster I indicate the presence of wide genetic diversity among the genotypes in this cluster. In fact genotypes forming single cluster were extra ordinary for one or more characters which made them so divergent from others. Although, the distance between various clusters was reflected in cluster means but it was differentiated for various characters as per their contributions towards total divergence among 68 genotypes. After considering the parameters of high seed cotton yield and response, GTSV 337, Laksmi, CNH 120, RS 810 and H 1236 were found most divergent and superior genotypes that can be exploited to produce high magnitude of heterosis or desirable segregants which would be meaningful for yield improvement in future breeding programme.

1.27
KR 64: A high yielding GMS based intra *arboreum* hybrid for Haryana state

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Intensive breeding programme was initiated during nineties to increase yield potential and disease resistance hybrids. Accordingly, genetic male sterility based *intra arboreum* hybrid KR 64 was developed. It out yielded 2303 kg/ha against 2031 kg/ha of AAH 1 by 13.39 per cent and local checks (different for different locations) by 34.05% in AICCIP North Zone, whereas mean seed cotton yield recorded 2457 kg/ha against 1911 kg/ha of AAH 1 by 28.57 per cent, 2690 kg/ha against 1281 kg/ha of HD 324 by109.99 per cent, 1912 kg/ha against 1422 kg/ha of CICR 2 by 34.46 per cent, 3060 kg/ha against 2517 kg/ha of RajDH 9 by 21.57 per cent and 1866 kg/ha against 1859 kg/ha of Moti by 0.38 per cent in Haryana, Rajasthan and Punjab, respectively under AICCIP trials. Adaptability to change in agronomic conditions, KR-64 gave significantly higher seed cotton yield at all the three locations. The per cent increase in seed cotton yield over CICR 2 was 9.60, 32.40 and 19.50 at Faridkot, Hisar and Shri Ganganagar, respectively. The row spacing of 67.5 cm x 60 cm gave significantly higher seed cotton yield over wider spacing. Among the fertilizer doses 100 per cent RDF

gave higher yield 3859 kg/ha. However, KR 64 was found resistant to bacterial leaf blight disease, comparatively tolerant to Fusarium wilt, root rot and fungal foliar leaf diseases as compared to check hybrids. It has a good yield potential of 3766 kg/ha coupled with early maturity and *at par* fibre quality. It is suitable for cotton raya/wheat rotation system and normal as well as late planting of Haryana state.

1.28
Evaluation of different American cotton genotypes at varying intra row spacing

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There is a need to identify the optimum intra row spacing in cotton at which the sympodial genotypes may give maximum yield potential. The present study was, therefore, undertaken to identify the desired intra row spacing for getting higher yield involving 12 cotton genotypes including 10 *Bt* hybrids viz. MRC7017, Maxxcot, MRC 6304, Bioseed 6488, Tulsi 4, OM 333, Ankur 2226, MRC 7031, VBCH 1534, Mist and two non *Bt* varieties *i. e.*, F 2383 and P 1752. The inter and intra row spacing of 75 x 60.0 cm and 75 x 30.0 cm were kept for *Bt* hybrids and 75 x 30.0 cm and 75 x 15.0 cm for non *Bt* genotypes. Recommended package of practices was followed to raise a good crop. Among the *Bt* hybrids MRC 7017 recorded highest seed cotton yield of 2662 kg /ha followed by Bioseed 6488 (2651 kg/ha), MRC 6304 (2387 kg/ha), MRC 7031 (1928kg/ha) and VBCH 1534 (1907 kg /ha) at closer spacing of 75 x 30cm. As far as non *Bt* genotypes were concerned P 1752 and F 2383 recorded seed cotton yield of 1238 kg/ha and 1056 kg/ha, respectively at closer spacing of 75 x 15cm and lowest seed cotton yield of 935 kg/ha was recorded in F 2383 and F 1752 at 75 x 30 cm spacing. Similar trend was observed in all the *Bt* and non *Bt* entries for lint yield where closer spacing gave higher lint yield as compare to wider spacing. Among the *Bt* cotton hybrids, boll weight with both closer and wider spacing was highest in MRC 7017 (5.49 and 5.18 gm) and lowest in OM 333 (3.46 and 3.33 gm). In non *Bt* genotypes, the boll weight of P 1752 was high *i. e.*, 4.15 and 4.53 gm in closer and wider spacing, respectively. Among the *Bt* hybrids Tulsi 4 BGII showed minimum height of 68cm at 30cm and 67cm at 60cm pant to plant spacing, whereas MRC 7017 showed maximum height of 122cm and 109cm in 30cm and 60cm plant to plant spacing, respectively It is concluded that *Bt* cotton hybrids can be grown successfully with narrow intra row spacing of 30cm and non *Bt* genotypes with 15 cm keeping wider inter row spacing of 75 cm for higher productivity.

1.29
Influence of different agro climatic conditions of Punjab on the performance of *Bt* cotton hybrids

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The State of Punjab has been classified into five agro climatic zones on the basis of homogeneity, rainfall pattern, soil texture and cropping patterns. Forty four *Bt* cotton hybrids of private sector along with two checks viz. MRC7017BG II and non *Bt* hybrid LHH 144 were evaluated in a randomized block design with three replications for yield and its component characters in two agro climatic zones of Punjab. The locations were Ludhiana which falls in zone III (Central plain zone) and Bathinda which falls in zone-V (Western zone also known as cotton belt). The objective of the study was to identify superior *Bt* cotton hybrids from private sector for higher yield and to assess the suitability of *Bt* cotton hybrids in different agro climatic conditions of Punjab. On the basis of mean of two locations only five hybrids *viz.* RCH569 BG II (2657 kg/ ha), NCS234 *Bt* (2612 kg/ha), RCH650 BG II (2446 kg/ha), PRCH7799 *Bt* (2365 kg/ha) and JK Tarzan BG-II (2377 kg/ha) gave significantly higher seed cotton yield than both checks *viz.* MRC7017 BG-II (1541kg/ha) and LHH144 (2066 kg/ha). The average seed cotton yield of forty four hybrids tested at Bathinda was higher (2179 kg/ha) as compared to tested at Ludhiana location (1731 kg/ha). The percentage increase in seed cotton yield was 25.9 at Bathinda as compared to Ludhiana. Similarly, the mean lint yield (720 kg/ha) and seed index (9.40g) of all the hybrids was also higher at Bathinda as compared to Ludhiana (lint yield of 594 kg/ha and seed index of 8.65 g). On the contrast mean ginning outturn was higher at Ludhiana (34.29%) as compared to Bathinda (33.08%). Differences were negligible for mean boll weight at both locations. At Bathinda the hybrid RCH569 BG-II exhibited highest seed cotton yield of 3286 kg/ha followed by 3210 kg/ha of NCS234 *Bt*, 2996kg/ha of NCS558*Bt* and 2867 kg/ha of NCS495 *Bt* and attack of whitefly and jassid was comparatively less on these hybrids. On the other hand the hybrids PRCH7799 *Bt* recorded highest seed cotton yield of 2390 kg/ha followed by 2331 kg/ha of JK Tarzan BG II, 2237 kg/ha of NBC51 *Bt* and 2119 kg/ha of RCH650 BG II at Ludhiana. As far as boll weight was concerned NSPL2223 BG-II and PCH5678 BG II at Bathinda and NCS189 BG II and SRCH666 *Bt* at Ludhiana location gave higher boll weight than checks. It is concluded from the study that agro climatic conditions at Bathinda location in western zone are more conducive for cotton cultivation and getting higher seed cotton yield than at Ludhiana location in central plain zone.

1.30
Combining ability studies for yield and its components in cotton *(Gossypium hirsutum* L)

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Combining ability analysis was carried out using line x tester design. Six lines and nine testers were crossed and 54 hybrids were developed during *Kharif 2006* to study seed cotton yield and fibre quality parameters. The parents, hybrids and three checks viz., PHH 316, NHH 44 and Bunny were planted in *Kharif2007* at different locations. Observations were recorded on 14 yield and yield contributing characters with an objective to estimate combining ability. The parental lines PH 348, PH 1009, PH 1024 and PH 297-7-1 were found as best general combiner for seed cotton yield per plant and other yield contributing characters. As regards the fibre quality the parents PH 1009, NH 545 and KH 121 were promising for 2.5 per cent span length, DHY 286-IR, PH 44-1-2 and KH 121 for micronaire value, PH 1009, PH 297-7-1 and KH 121 for fibre strength, PH 348, PH 1024 and PH 297-7-1 for fibre elongation and KH 120, NH 545 and NH 572 for uniformity ratio were good general combiners. In respect of specific combining ability the hybrids KH 121 x PH 1024, KH 120 x NH 545, KH 121 x PH 348 and PH 297-7-1 X PH 1024 had shown positive significant sca effects not only for seed cotton yield per plant but also for important yield contributing characters and fibre properties.

1.31
Breeding American cotton genotypes suitable for high plant density

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Although India ranks 1st in cotton area (12.2 m ha) and 2nd in production (27.0 m bales), its productivity of 482 kg lint/ha is very low as compared to China (1320 kg/ha), Brazil (1446 kg/ha), Australia (1802 kg/ha), Turkey 1406 kg/ha) and USA (865 kg/ha) (anonymous 2011). This is in spite of the fact that more than 85 per cent area under cotton is occupied by hybrids. Hence, there is a need to enhance the productivity with perspective plan like discontinuation of cotton cultivation in the areas of low productivity and identification of new or non-traditional areas which can boost the yield. Another option is to increase productivity by evaluating cotton varieties under high plant density as practiced in Brazil, USA, China, Uzbekistan etc, where plant population of 1 to 2 lakh/ha is maintained as compared to 6000 – 15000 plants/ha in India. Since a major cotton growing area in India is under hybrids having higher seed cost, thus increasing plant population with hybrid varieties will put extra cost to the farmers. Therefore, it is a priority area of research to develop open pollinated varieties of cotton having compact genotypes suitable for high plant density to increase the productivity level. Systematic research efforts were initiated in this direction at PAU Regional Station, Faridkot which resulted in the development of a number of promising genotypes having dwarf stature, low foliage, low internodal distance and low plant width. Out of these, 14 promising genotypes

were evaluated at two spacings, i.e., normal (67.5 × 60.0 cm) and narrow (75.0 × 15.0 cm) by maintaining a plant population of about 25000 and 90000/ha, respectively. The non-Bt varieties, LH 2076 and F 1861 and Bt hybrid MRC 7017 were included as checks. The seed cotton yield varied from 1509 kg/ha in genotype FB 10 to 3094 kg/ha in FB 13 under normal spacing. The seed cotton yield of standard varieties were 2225 kg/ha in LH 2076, 1981 kg/ha F 1861 and 2835 kg/ha in MRC 7017. On the contrary, under narrow spacing of 75.0 × 15.0 cm, the seed cotton yield varied from 1838 kg/ha in genotype F 2383 and F 1861 to 2990 kg/ha in FB 1. Out of 15 genotypes, 12 gave higher seed cotton yield under narrow spacing as compared to that under normal spacing. The genotype FB 1 gave 2990 kg/ha seed cotton yield under narrow spacing in comparison to 1890 kg/ha under normal spacing. Similarly, the seed cotton yield of FB 12 was 2936 kg/ha under narrow spacing and 2439 kg/ha under normal spacing. Two genotypes, FB 8 and FB 13 and check F 1861 gave lower yield under narrow spacing in comparison to that under normal spacing. The incidence of insect-pests especially bollworms and sucking pests and cotton leaf curl disease was almost similar under both the spacings. The results of our study showed that the genotypes, FB 1, FB 10, FB 12, FB 14, FB 5 and FB 6 had a great potential under narrow spacing and need to be evaluated further for yield and fibre quality.

1.32
Genetic studies of variability, correlation and path coefficient analysis in cotton genotypes

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Variability, correlation and path coefficient studies were conducted using 8 Lines and 7 Testers and their 56 F_1s made with the parents of *G.hirsutum* and *barbadense* genotypes of diverse origin. The phenotypic coefficient of variation which measures the total variation was found to be greater than the genotypic coefficient of variation in majority of characters. The closer magnitude of GCV and PCV indicated that genotype has played greater role rather than environment. High heritability coupled with high genetic advance was noticed for the characters seed yield/plant, number of bolls/plant indicating the presence of additive gene action in the expression of these traits. Correlation studies revealed that seed cotton yield had positive significant correlation with number of bolls/plant and fibre length (mm). Number of bolls/plant had significant positive association with plant height and fibre length. The positive significant correlation was observed for seed index, lint index and micronaire value with boll weight at genotypic and phenotypic level. Thus for increasing seed cotton yield in cotton due emphasis should be given to number of bolls/plant, boll weight (g), seed index, lint index and fibre length (mm) characters. Path coefficient analysis revealed that number of sympodia/plant, number of bolls/plant, boll weight (g), seed index and lint index directly influenced the seed cotton yield with high direct effects. It was concluded that these characters could be considered as significant selection criteria for seed cotton yield improvement in cotton.

1.33
Studies on flowering behaviour and fruiting pattern of some early maturing germplasm lines of *Gossypium barbadense* L

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The flowering behaviour and fruiting pattern of some early maturing germplasm lines of *G.barbadense*, L. was studied during the course of morphological characterization of *G.barbadense* germplasm to understand the relationship of flowering and fruiting behaviour with yield and fibre quality parameters. The results revealed that prolonged flowering and boll formation period was longer in early maturing genotypes than the late maturing. In genotype ICB-6, ICB-29, ICB-127, ICB-286, ICB-191, ICB-204, ICB-22 ICB-167 ICB-129 ICB-162 ICB- 204 more number of flowers were produced, however, mature bolls per plant were low due to higher shedding percentages. It was noted in accessions ICB-164, ICB-114 and ICB-260, 72 percent of flowering over at the end of September, while most of the others completed their maximum flowering in the second week of October. The maximum boll formation in the week of 25th to 14th October was noted in ICB-22, ICB-127, ICB-204, ICB-114 and ICB-260. Though all the 15 genotypes are early maturing, only five genotypes have been identified as high yielding types. From this study, fourteen distinct fruiting patterns were identified. Normally *G.barbadense* produces long sympodial branches which have 4-5 bolls per branch in equal distance. But some of the exotic *G.barbadense* lines are short branching types, having cluster fruit bearing habit. The number of bolls per cluster varies from 2-5. From these observations it was concluded that information pertaining to flowering behaviour and variability in fruiting pattern are highly helpful for the effective utilization of *G.barbadense*, L. germplasm in the breeding programme and subsequent identification to progenies with desired characters. From the flowering studies, the genotypes ICB-6, ICB-204, ICB-114 and ICB- 260 were identified as early maturing genotypes with minimal square shedding and maximum boll retention ability as compared to other germplasm lines under Coimbatore weather conditions.

1.34
Exploration, collection and conservation of perennials and landraces of cotton from different regions of India

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Cotton is the world's leading fibre crop and second important oilseed crop. India is the ancient home of the cultivated Asiatic species of *Gossypium* L. particularly representing the origin and domestication of three geographical races of *G. arboreum* L., namely bengalense, cernuum and indicum and also the race wightianum of *G. herbaceum*. In the era of climate change, frequent occurrence of flooding and severe drought will be common. Minor insects and diseases are becoming major problems in the cropping systems. So, it is necessary to collect, conserve and utilize our invaluable national germplasm resources for the benefit of the Indian cotton farmer. With the help of KVKs of the particular districts, exploration and collection trips

were carried out to Bhandara, Nagpur, Washim, Parbhani and Wardha districts of Maharashtra, Sehore district of Madhya Pradesh, Jalpaiguri district of West Bengal, Jammikunta, East Godavari, West Godavari, Vishakapatnam, Vizianagaram and Srikakulam districts of Andhra Pradesh, Theni district of Tamil Nadu, Pondicherry, Faridkot and Mansa districts of Punjab and Assam, Meghalaya and Mizoram of Northeastern states. Landraces of Desi cotton particularly *G. arboreum* race indicum and *G. arboreum* race *cernuum* were collected from Ponduru mandal, Srikakulam district, Andhra Pradesh and West Garo Hills, Meghalaya respectively. A total of 108 germplasm accessions were collected from exploration trips. On the basis of morphological observations/traits, 82 samples were perennials and landraces of *G. arboreum* while 26 samples represented *G. barbadense* . The range of 2.5% span length and fibre strength varied from 21.2 to 25.2 mm and 16 to 21.1 g/tex respectively in case of *G. arboreum*. The range of 2.5% span length and fibre strength varied from 28.3 to 34.2 mm and 20.6 to 23.6 g/tex respectively in case of *G. arboreum*.

BIOTECHNOLOGY

1.35
Need and relevance of association mapping, using molecular markers, for fibre quality improvement in *Gossypium arboreum* L

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Various traditional breeding efforts to improve the fibre traits of *G. arboreum*, without disturbing the quality characters of it, have met with limited success. Over the years, the molecular markers have come out as invaluable tool kit and central to the genomic tool kit is the molecular map which provides a common point of reference for dissecting the quantitative traits for a host of phenotypes. Association mapping based on linkage disequilibrium where collection of cultivars, lines, landraces are genotyped with densely spaced markers is emerging out as a better alternative to linkage mapping because it allows screening of a broader genetic variation in a more representative background, is not limited to marker and trait loci that happen to differ between two parents and can attain a higher resolution because of the use of all the meiosis accumulated in the breeding history. The studies on association mapping of *G arboreum* for fiber quality traits will help in identifying the QTLs/genes associated with the traits and will be a great guide to the future breeding programmes.

1.36
Cotton fibre quality evaluation and the promising future with nanotechnology

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The price of cotton fibre and profit to the grower depends upon the quality of cotton fibre. Cotton fibre quality is no longer an afterthought and generally refers to staple length, fineness, fibre strength and fibre elongation. All these parameters are taken into account to evaluate the quality. Various techniques are used for the fibre quality evaluation like HVI (High Volume Instrumentation), Bootstrap simulation, Utility value concept, AFIS (Air flow Particle Sizer), Ca-XRF (Calcium weight ratio quantization by X-Ray fluorescence etc. The quantification of the quality of cotton fibre is meaningful only if strategies are developed to improve the quality further. 25 per cent of cotton fibre is lost to scrap during its processing. Electro spinning technique can be used to change scrap into low value products like cotton balls, yarn and cotton batting. The tensile strength and thermal stability of the fibre can be enhanced by Chemical oxidation deposition technology. Nano particles like titanium oxide can be used with organic and inorganic compounds to make the surface of fabrics abrasion resistant and for UV protection. Wrinkle resistance of cotton fabrics can be enhanced using nano engineered cross link agents. Soft shell technology provides for air permeable and comfort clothing. Ag nanoparticles impart antibacterial properties to cotton; Au nanoparticles can trap viruses, Pt and Pd nanoparticles impart catalytic properties like decomposition of harmful gases or toxic chemicals. Most importantly that it can be done without affecting the texture and comfort of cotton. We can also imagine coating a cotton fibre with clay nanoparticles that would prove to be environmentally friendly, flame resistant and durable goods. So, cotton can be changed from an old fashioned material into a fabric for the future using nanotechnology.

1.37
Genetic purity analysis of cotton (*Gossipium hirsutum* L) seeds on the basis of storage protein profiling

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In recent years variety identification and diversification has been achieved in range of agricultural crops by means of electophoretic techniques. Present study was undertaken with the objective of diversifying and identifying two cotton seed lots on the basis of seed storage protein profiling to check the genetic purity. When seed storage protein pattern of two cotton seed lots (H1098 from HAU and cotton seed collected from farmers to be same variety) were analyzed, a high similarity index (77%) within HAU cotton seed lots indicated closed evolutionary relationship *i.e* they are genetically closely related while low value of similarity

index (66%) within farmer’s cotton seed lot indicated that they are not genetically pure. When comparison was made between two cotton seed lots we come to the conclusion that only 25 per cent of the farmer seed lot matches with HAU seed lots. Final results came out to be that farmer and HAU cotton seed lots are genetically different. There are several findings reporting that seed protein profile comparison are better than field grown out test for determining genetic purity. In our study we concluded that this method may be considered useful for the genetic purity test of the seed as it is less time consuming than the scoring at seedling stage or morphometric parameters. Although electrophorogram is not used for seed certification at present , it is in vogue for the house quality control and provides a mean to allow a quick decision to acceptance to marketing of seedlot. It is of immense commercial value for the quality control of cotton seeds.

1.38

Screening of thermo sensitive genetic male sterility (TGMS) lines of diploid cotton (*Gossypium arboreum* L) for their critical sterility and fertility behaviour

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Seven lines of TGMS were taken which were isolated from one one (1-1) material based on its phenotypic as well as its TGMS behavior at CICR Nagpur. Pl 3-5, Pl 10-7, Pl 11-12, Pl 12-4, Pl 16-14, Pl 27-9 and Pl 38-8 were screened during 2011-2012 at ARS, Dharwad. Seven lines except of 27-9 showed increased fertility levels along with decreased weekly mean minimum temperatures during last four weeks of the study. None of the line in the present study expressed complete sterility during the study, because we did not come across more than 24 ^{0}C weekly mean minimum temperatures which is basic temperature to obtain complete sterility in cotton under field conditions .It revealed that we have to choose areas, where the mean minimum temperatures will be more than 24 ^{0}C for hybrid seed production without fluctuations. As for as seed multiplication is concerned, ARS Dharwad is well suitable during November to February during which the mean minimum temperatures are low and sufficient to ensure selfing or seed multiplication of TGMS lines. Present investigation also indicated that 18^{0}C weekly mean minimum temperature is enough to maintain high fertility levels under field conditions.

1.39
Bioefficacy of selected isolated *Bacillus thuringiensis* strains against *Helicoverpa armigera*

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Harmful residual effects of chemical insecticides have diverted our attention to use *Bacillus thuringiensis* based bio insecticides for specific insect control. An attempt has been made to isolate and characterize native strains of *Bacillus thuringiensis* (*Bt*) effecti ve against *Helicoverpa armigera* (from soil and dead insect larvae). Of the total sixty *Bt* isolates (20 from soil and 40 from larval cadavers) 4 isolates L 10, L 32, L 33 and S 14 caused 100 per cent mortality of larvae of *H. armigera*. Selected *Bt* strains *Bacillus thuringiensis* preparations. Dipel and Halt both under laboratory and field conditions were more effective in controlling the larvae of *H. armigera.*

1.40
Polyphenolics and polysaccharides free DNA isolation from cotton leaf curl diseased plants and whitefly

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Cotton DNA prepared with plant DNA isolation methods often is found to be impure and laden with phenolics and excessive polysachharides. A method for reproducible preparation of cotton genomic DNA suitable for PCR analysis is presented. Genomic DNA for cotton leaf curl diseased samples were isolated by using a modified method using CTAB. Diseased leaf tissue was ground to a fine powder with or without liquid nitrogen and dispersed in 20ml pre warmed (60°C) extraction buffer (0.1 M of Tris/HCl pH 8, 0.01 M of EDTA, 0.6 M of NaCl, 2 per cent of â-mercaptoethanol and 2% CTAB). A PVP concentration of 2 per cent was used in extraction buffer to remove phenolic compounds from high molecular weight cotton genomic DNA. After incubation for 1 h at 60 - 65°C with intermittent swirling, the mixture was mixed with an equal volume of chloroform-isoamyl alcohal (24:1). Following centrifugation the supernatant was collected and mixed with 0.6 volume of isopropanol. The precipitated nucleic acid was spooled out, washed in 70 per cent ethanol, dried and dissolved in TE buffer. Cotton DNA was treated with a mixture of NaCl (0.75 M) and CTAB (1%) for removal of excess polysaccharides. The RNA was removed by 3 il of RNase A (25 µg/ml) treatment of cotton DNA. The processed DNA was phenol : chloroform extracted and ethanol precipitated. The quality and quantity were estimated by measuring O.D. at 260 nm and 280 nm, respectively. Intactness and extent of shearing of genomic DNA was analysed on 0.8 per cent agarose gel by submarine electrophoresis. The observations on DNA content and quality as well as results of various modifications in protocol shall be presented.

1.41
Characterization of *Bt* cotton (*Gossypium hirsutum*L*)* hybrid varieties for their relative expression of cry proteins in Haryana

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Majority of Indian *Bt* cotton varieties are the outcome of an event 531 and used later to introgress cry genes in diverse varieties. The event 531 involved stable insertion of a gene sequence encoding the Cry1Ac protein into the cotton genome. The event 531 (Cry1Ac) and MON 15985 event (Cry2Ab) proved very effective in providing protection against select pests. Leaves from diverse *Bt* cotton hybrid varieties sampled at 90 and 120 days after sowing have been assayed. *Bt* toxin (cry 2Ab protein) levels in the leaves from 21 *Bt* cotton varieties from Sirsa ranged between < 2.0 to 11 ng/ml. The *Bt* toxin levels in 11 of the 21 samples at 90 DAS and 120 DAS had toxin levels less than or equal to 3ng/ml and one had as much as 11 ng/ml. Relatively samples from Hisar in general, had higher cry2Ab levels with as much as 5 of the 18 samples recorded toxin more than 15 ng/ml. From published reports it is concluded that cry levels to the tune of 2.5 ng/ml or more provide sufficient protection against cotton insect larvae. In general Bt toxin (*cry* protein) levels in the leaves from *Bt* cotton varieties from Hisar Fatehabad and Sirsa were determined and cry2Ab expression was found more than that of cry1Ac. The later was not detected in general from all the samplings. cry2Ab expression ranged between <2.0 to 7 ng/ml. The *Bt* toxin levels in samples at 90 DAS had toxin levels less than or equal to 3ng/ml. Relatively samples from Hisar in general, had higher *cry2Ab* levels.

1.42
Isolation of gossypol biosynthesis gene for RNAi vector construction

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Cottonseed is an important byproduct of the fiber production. The protein content and protein efficiency ratio is higher than that of number of other major vegetable proteins but the full utilization of nutrient rich cotton seed is hampered by presence of toxic gossypol which makes it toxic to humans and monogastric animals. The Reduction of toxic gossypol exclusively in seed will have immense practical value to improve cotton seed utilization. The present experiment was carried out to isolate gossypol biosynthesis gene encoding ä *cadinene hydroxylase* to prepare RNAi vector for silencing gossypol biosynthesis in seed. Primer has been designed to amplify 534 bp conserved target sequences of gene encoding for *ä cadinene hydroxylase*. The target sequence was PCR amplified, sequenced and confirmed through homology based search. Further, the target sequence was amplified in sense and anti sense orientation for construction of intron hairpin RNA interference vector.

1.43
Molecular characterization of working collection of cotton (*Gossypium hirsutum* L) using microsatellite marker

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Cotton, a leading fiber crop in the world, is also an important source of edible oil and seed meal and plays a prominent role in the national and international economy. Cotton belongs to the genus *Gossypium* of *Malvaceae* family. It comprises about 50 species including diploid and tetraploid species out of which only four species are cultivated. Effective use of *Gossypium hirsutum L.* lines in cotton genetic improvement programs depends on the extent of genetic variation for desirable alleles and the accurate characterization of the variability among germplasm accessions. Now-a-days SSRs are becoming the markers of choice due to high level of polymorphism, reliability, co-dominance inheritance and genomic coverage. These are useful in species where low level of genetic diversity limits the use of other marker techniques. In the present study, we employed SSR markers to reveal genetic diversity in the working collection of cotton (*Gossypium hirsutum* L.) which comprised 391 accessions belonging to different quality traits groups. Approximately, 300 SSR primer pairs were screened, out of which 44 primer pairs were found to amplify clear, sharp and polymorphic bands. Upon PCR amplification, the alleles were separated on 8% polyacrylamide gel and visualized by ethidium bromide staining. Using these 44 primer pairs, 62 SSR loci and a total of 230 alleles were obtained with an average of 3.7 alleles per locus. Out of 230 alleles, 212 were polymorphic across the accessions (92.17%) and average no. of polymorphic alleles per SSR loci was 3.4. Values of polymorphic information content (PIC) for each marker ranged from 0 to 0.85 with an average of 0.71. The UPGMA (Unweight Pair Group Method with Arithmetic Mean) clustering analysis at the genetic similarity value of 0.51 grouped the 391 accessions into three clusters. Cluster I comprised of 384 accessions, which were highest in number while cluster II and III comprised two and five accessions, respectively. These SSR primers would be helpful in systematic genetic assessment of the gene resources to decrease redundancy and to construct a core germplasm collection, which is important for efficient use of these genetic resources in cotton breeding.

CROP PRODUCTION AND MECHANIZATION

POSTER PRESENTATION

2.1
Response of *Bt* cotton to method of sowing in irrigated ecosystem

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A field trial was conducted during *kharif* 2008-2009 to study the response of *Bt* cotton to different methods of sowing in black soils under irrigated ecosystem at Agricultural Research Station, Siruguppa. The experiment was laid out in randomized block design with three replications. The experiment consists of 7 treatments viz., T^1: Transplanted water cup nursery of 21 days old seedlings, T^2: Transplanted water cup nursery of 28 days old seedlings, T_3: Transplanted ploythene bag nursery of 21 days old seedlings,T_4: Transplanted polythene bag nursery of 28 days old seedlings,T_5: Direct seeding one seed/hill, T_6: Direct seeding of two seeds/hill and T_7: Sowing after receipt of canal water. The recommended dose of fertilizer 150:75:75 kg NPK with + 2 sprays of 2 per cent of DAP at flowering and boll formation was followed for all the treatments. The *Bt* cotton hybrid Bunny *Bt* (NCS-145) BG II was dibbled with a spacing of 90 x 60 cm spacing and recommended practices are common to all treatments. The results of the experiment indicated that, highest seed cotton yield was noticed in direct seeding of two seeds/hill (2240 kg/ha).This higher yield was mainly attributed to higher number bolls/plant (27.27) and more seed cotton yield/plant (102 g/pl). Whereas, higher plant height was recorded in T_3 (Transplanted with ploythene bag nursery at 21 days age old seedlings) followed by T_1 (Transplanted water cup nursery at 21 days old seedlings) and the least is in T_7. Direct seeding of *Bt* cotton two seeds/hill was found to be the best method of sowing under irrigated condition.

2.2
Agronomic strategies for sustainable use of poor quality irrigation water in *Bt* cotton wheat cropping system

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A 3-year field study was conducted at Research Farm of the Punjab Agricultural University Regional Station, Bathinda, (30°9' N and 74°56'E; altitude 211 m a.s.l.) from 2005-2006 to 2007-2008. The experimental site forms a part of the Indo-Gangetic alluvial plains which were formed with varying pleistocene and recent alluvial deposits of the rivers of Indo gangetic system. The site is semi-arid (dry), with mean rainfall of 401 mm. Rainfall is monsoonal in nature, 70 to 80 per cent is received during the months of July, August and September, coincide with the active growing season of *Bt* cotton. The experiment was conducted to evaluate the response of each furrow and alternate furrow irrigation in hybrid *Bt* cotton - wheat cropping system using irrigation waters of different qualities. Irrigation was applied to each and alternate furrow on bed-planted wheat followed by ridge-planted cotton for comparison with standard check basin method of irrigation

to both the crops. Three water qualities namely good quality ?water (GW), saline-sodic water (SSW) and pre-sowing irrigation to each crop with GW and all subsequent irrigations with SSW (GWpsi+SSW) were evaluated under three methods of irrigation (check-basin , each furrow and alternate furrow). The pooled results over 3 years revealed that wheat grain yield was not affected significantly with quality of irrigation water. However, significant wheat yield reduction was observed in alternate bed irrigation in all water qualities. In hybrid *Bt* cotton, saline sodic water (SSW) significantly reduced the seed cotton yield in all the three methods of planting. The pre sowing irrigation with GW and all subsequent irrigations with saline sodic water improved the seed cotton yield as compared to the application of saline sodic water alone. However, in alternate furrow the yield increase was significant and the yield obtained was equal to the yield under alternate furrow in GW. Reduced use of irrigation water under alternate furrow resulted in 21, 21 and 25 per cent higher water use efficiency in wheat under GW, SSW and GWpsi+SSW, respectively. The corresponding increase under *Bt* cotton was 28, 19 and 36 per cent.

2.3
Effect of sowing dates and irrigation levels on yield and quality characters in cotton

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A field experiment was conducted for two consecutive years during *kharif* 2010 and 2011 at CCS HAU Cotton Research Station, Sirsa. The main objective was to study the effect of sowing dates and irrigation levels on seed cotton yield and quality characters in cotton. Four different sowing dates (D_1 - 3rd week of April, D_2 - 2nd week of May, D_3 - 3rd week of May and D_4 - 2nd week of June) were signed to main plots whereas three levels of irrigation (I_1=0.3, I_2 =0.4 and I_3 =0.5 ID/CPE up to 65 Days and (I_1=0.4, I_2 =0.6 and I_3 =0.8 ID/CPE after 65 Days) were allocated to sub plots. Highest mean seed cotton yield (3022 kg/ha.) was observed when sowing was done on 3rd week of April. It was found that in delayed sown crop seed cotton yield significantly decreased and lowest seed cotton yield (1886 kg/ha.) was observed with D_4 sowing. Seed cotton yield decreased 3.21 per cent in D_2 , 4.58 per cent in D_3 and 35.28 percent in D_4 sowing as compare to D_1 sown crop of cotton. However, seed cotton yield was *at par* in all three irrigation levels but it was highest (2667 kg/ha.) in I_2 =0.4/0.6 ID/CPE. Some fibre quality characters namely ginning out turn (GOT %) was non significantly and not affected by different sowing dates and irrigation levels. Hence, for getting the maximum seed cotton yield with quality, product, the crop should be sown on 3rd week of April with irrigation level of 0.4/0.6 ID/CPE under the agro climatic conditions of semi arid zone of haryana.

2.4
Impact of conservation tillage and integrated nutrient management through biomass recycling of pigeonpea based intercrops cotton sequence

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The experiment was conducted during 2010-2012 for two years rotation of pigeonpea based intercropping system followed by cotton at Agronomy farm Dr PDKV Akola. The soil was medium deep with medium nitrogen ,low in phosphorus and high in potassium. The treatment consist of two tillage practices (conventional and conservation tillage), three intercropping system *viz.*, pigeonpea + soybean (1:2), pigeonpea + sunhemp (1:2) and pigeonpea + soybean(1:5) in first year under FRBD with four replications and in second year on same layout integrated nutrient management through in situ biomass recycling of previous cropping system was studied in Bt cotton with spilt plot design . The four nutrient management levels for cotton were shed biomass of previous crop, shed biomass + 50 per cent N VC(from pigeonpea stalks), shed biomass + 50 per cent RDF + 50 per cent N (VC) and shed biomass + RDF (60:30:30). Rainfall during first cropping season was 846.6mm and in second season was 461 mm. The pigeonpea equivalent yield (PEY) in first season and seed cotton yield (SCY) were not influenced by tillage practices and cropping system. The highest PEY and net returns were obtained from pigeonpea + soybean (1:2) and which is *at par* with pigeonpea + soybean(1:5) in first year. Maximum biomass was available for recycling from pigeonpea + sunhemp (1:2) intercropping for next season cotton crop. In second season, SCY (1219 kg/ha) was produced when pigeonpea + sunhemp (1:2) was grown in previous year and, SCY (1288 kg/ha)was obtained, when RDF applied to cotton with shedbiomass of previous system.. The highest soil values of OC,SMBC and NPK were observed after harvest of cotton when pigeonpea + sunhemp (1:2) was grown in previous year and shed biomass + 50 per cent RDF + 50 per cent RDN through vermicompost to cotton.

2.5
Plant geometry and nutritional management in *Bt* cotton based inter cropping system under Saurashtra region

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A field experiment was conducted at Cotton Research Station, Junagadh Agricultural University, Junagadh during two consecutive years of k*harif* 2010-2011 and 2011-2012. The experiment comprising of twenty four treatment combinations *viz.*, three inter cropping systems ($I_{1=}$Cotton-Pigeonpea, 1:1 row ratio, $I_{2=}$ Cotton-groundnut, 1:2 row ratio, $I_{3=}$ sole cotton), two spacing ($S_{1=}$120 x 30cm and $S_{2=}$120 x 45cm) and four nutrient management practices (F_1= 100% RDF + foliar spray of 1.5% DAP + 0.5% K at flowering stage, $F_{2=}$ F_1 + $MgSO_4$ (50 $kgha^{-1}$) + boron as solubor (2.0 kg/ha) + foliar spray (1.5% DAP + 0.5% K + 0.5% $MgSO_4$ + Boron as solubor, 0.15%) twice during flowering to boll development stages, F_3- (125% RDF (N and K in 4 equal splits)

+ foliar spray (1.5% DAP + 0.5% K) and F_4- (F_3 + foliar spray of 0.5% $MgSO_4$ + boron as solubor (0.15%) twice during flowering to boll development stages and it was laid out in factorial randomized block design with three replications. Cotton *Bt* hybrid (NHH 44), groundnut (cv.GG 20) and pigeonpea (cv. BDN 2) were sown as soon as onset of monsoon. Inter crops were fertilized as per recommendations made for each crop. Nutrient management followed as/treatment in base crop of cotton. Other packages of practices were followed as per recommendations made for the base and intercrops. Two years pooled results showed that significantly maximum seed cotton (2814 kg/ha) and lint (946 kg/ha) yields were recorded under sole cotton crop. Whereas, maximum cotton equivalent yield (2848 kg/ha), gross (119631/ha) and net realization (80263/ha) were observed when pigeonpea inter cropped with cotton in 1:1 row proportion. Sowing of cotton at 120 x 30cm row spacing produced numerically higher seed cotton, lint and cotton equivalent yields and gross and net realization. Application of 125 per cent recommended NPK (N and K in 4 equal splits) + foliar spray of 1.5 per cent DAP + 0.5 per cent K + foliar spray of 0.5 per cent $MgSO_4$+ boron as solubor (0.15%) twice during flowering to boll development stages recorded significantly highest seed cotton (2104 kg/ha), lint yield of 705 kg/ha and cotton equivalent yield of 2303 kg/ha. Numerically, higher gross realization of 11773/ha, maximum net realization (75343/ha) and B:C ratio (1.91) were obtained when cotton crop fertilized with 125 per cent RDF (N and K in 4 equal splits) + foliar spray of 1.5 per cent DAP + 0.5 per cent K.

2.6
Effect of land configuration and nutrient modules on productivity of cotton under dryland conditions

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The experiment was conducted at the field of Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth , Akola during *kharif* season 2009-2010. The study was undertaken to know the effect of land configuration and nutrient modules on productivity of cotton under dryland conditions. The experiment was laid out in split plot design with three replications. Land configuration treatments were taken in main plot and nutrient modules in sub plot. Land configuration comprises four treatment *viz.*, L_1- flat bed, L_2- ridges and furrows, L_3- opening of furrows after every two rows (30DAE) and L_4 -opening of furrow in each row (30DAE). Nutrient modules comprises of five modules *viz.,* M_1 -(100% RDF 50:25:25 kg NPK/ha) through chemical fertilizers, M_2- (10t FYM +PSB +*Azatobacter*, M_3- (50% RDF + FYM @ 5 t/ha PSB+*Azatobacter*, M_4- (vermicompost @ 2.5 t/ha + PSB +*Azatobacter* and M_5- (Glyricidia @ 10t/ha +PSB+*Azatobacter* . Results revealed that the effect of land configuration was found significant. Treatment L_4 recorded highest seed cotton yield of 968kg and stalk yield 3744kg/ha followed by treatment L_2 (946kg/ha) which was comparable. In nutrient module, M_3- recorded significantly higher seed cotton (973kg/ha) and stalk yield (3832kg/ha) which was *at par* with M_1- and M_5. Interaction effect of land configuration and nutrient module on seed cotton yield were found non significant but in case of stalk yield it was significant. The stalk yield (4586kg/ha) was significantly highest in L_4M_3. Benefit cost ratio was maximum L_4. In nutrient modules, M_1 recorded maximum B:C ratio of 1.97.

2.7
Impact of drip irrigation on productivity of *Bt* cotton in Sirsa district of Haryna

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The present study was conducted to assess the impact of DMI over FMI, on productivity of *Bt* cotton in Sirsa district of Haryana. To achieve the objective of the study, primary data on various cost components were collected, analysed and compared for both the method of irrigations. The results revealed that DMI reduced the cost of cultivation especially in operations like irrigation (40%), weeding and inter culture(36%), preparatory works (26%) and 28 per cent less quantity of seed required. Water and electricity saving are the two significant advantages of drip method of irrigation. The number of irrigatins used for drip irrigated of *Bt* cotton were 48 substantally higher than that of flood irrigated crop (6), however the hr. used for each turn of irrigation was about 40 min./ac. under DMI as against the use of 7.90/hr under FMI. Thus, farmers were able to save 118 H.P. hr of water/ac which was about 33 per cent saving over FMI DMI substantially reduced the working hr of pump set by reducing the water consumption. It is calculated that 0.750 kwh of power is used/HP for every hour of pumpset operation. As per the estimates the consumption of electricity under DMI was only 179 kwh/ac as against 267 kwh/ac under FMI, indicating a saving of 88 kwh/ac. The productivity of cotton cultivated under DMI (12.50 q/ac) was found about 33 per cent higher than under FMI which is 9.10 q/ac. The results of the study, thus clearly suggested that cultivation of cotton crop under drip method of irrigation would greatly benefit the farmers.

2.8
Socio economic assessment and policy initiatives for climate change risk management in cotton production technologies

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Front line demonstrations were carried out consecutively for four *kharif* seasons (2005-2008) at 135 irrigated farmers' fields in Hisar district to evaluate the performance of promising *Bt* cotton hybrids *viz.,* MRC 6301,MRC 6304, JKCH 1947, RCH 317, NCS 913, MRC 6025 and compared with RCH 134 under major cotton-wheat rotation through Krishi Vigyan Kendra, Sadalpur. The *Bt* hybrids were assessed for their productivity, economic returns and benefit: cost ratio. The crop was sown during first fortnight of May of each year on sandy loam to loam soils with planting geometry of 90 x 45 cm / 67.5 x 60 cm. The crop was raised as per package of practices recommended for released hybrids of American cotton. Prevings ranging done (2-3 pickings) up to second week of November gave average seed cotton yield in the ramgi of 17.1 to 30.6 q/ha. The net returns and benefit: cost ratio were found ranging from Rs 12000 to Rs 31800/ ha and 1.92 to 4.50, respectively. Timely advisory services to the farmers were rendered through trainings/ visits/ mobile phones for adopting the strategies to lessen the vagaries of the nature. Weather parameters pertaining to seasonal rainfall, the average maximum and the minimum temperatures, bright sunshine (hr), relative

humidity values at morning and evening (hr), rainy days (> 2.5 mm rainfall) and pan evaporation from sowing to early growth, flowering to fruiting stage and boll setting to picking stage are highlighted in this study. Timely technical knowhow, congenial agro climatic conditions, highly efficient extension net work, good resource management and market stability are required to attain full production potential of *Bt* cotton hybrids.

2.9
Biochemical evaluation of cotton genotypes to ascertain their basis for tolerance/susceptibility to CLCuV disease

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Seeds and leaves of sixteen cotton genotypes (Br02 122, 125, 126, 129, 138, 140, 141, BR03 1011, BR04 1030, Br05 1042, HS6 healthy, HS6 diseased, MRC 6304 healthy, MRC 6304 diseased, RCH 134 healthy and RCH 134 diseased) were analyzed for protein, oil, phenol, tannin, nitrogen and gossypol content using standard methods. It was observed that phenol content was lowest in Br02 141 (1.36%) and highest in MRC 6304 healthy (4.10%) in leaves and in seeds it was lowest in Br05 1042 (1.10%) and highest in MRC 6304 healthy (2.20%). The tannin content was lowest in Br02 125 (5.80%) and highest in MRC 6304 healthy (11.55%) in leaves and in seeds whereas it was lowest in Br02 141 (1.49%) and highest in Br03 1011 (2.11%). The nitrogen and protein content in leaves were lowest in Br02 141 (2.40% and 15.05%, respectively) and were recorded highest in Br03 1011 (4.31% and 26.95%, respectively). In seeds, it was lowest in RCH 134 diseased (2.01% and 12.60%, respectively) and highest in Br03 1011 (2.60% and 16.27%, respectively). The oil content was highest in RCH 134 healthy (35.10%) and lowest in Br02 141 (17.10%) in seeds. The gossypol content was lowest in HS6 healthy (0.60%) and highest in Br02 141 (0.82%) in seeds.

2.10
Effect of sodium chloride (NaCl) stress on osmotic adjustment, growth attributes and proline content in cotton cultivars differing in salt tolerance

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The present investigations were conducted to study the effect of salt stress (50-150 mM salt) on growth characteristics, osmotic adjustment and proline content in two cotton cultivars differing in salt tolerance *viz.* H 1236 (salt-sensitive), H 1226 (salt tolerant). In both the cultivars, osmotic potential became more negative with increasing level of salinity and was accompanied by a decrease in relative water content. The cultivar H 1236 showed more reduction in RWC with higher decline in osmotic potential. The germination per cent and rate of germination was higher in H 1226 as compared to H 1236 under different levels of salt

stress. The salt stress upto 100 mM had no effect on seedling dry weight of H 1226 whereas in H 1236 even 50 mM NaCl resulted in significant decrease in dry weight. The proline content increased in both the cultivars with increased in salinity level but the level of increment as well as the basal level were much higher in salt-tolerant cultivar H 1226 as compared with the sensitive cultivar H 1236. Leaf tissue of H 1226 as compared with H 1236, had lower levels of sodium, maintained higher K/Na ratio, and accumulated proline at higher levels under salt stress. Results presented suggested that cultivar H 1226 might have enhanced capacity of osmotic adjustment , more K+ uptake and higher accumulation of the proline under NaCl stress conditions, could be survived better thus imparting stress tolerance.

2.11
Effect of weather on *Bt* Cotton

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A field experiment was conducted on clay soils of Regional Agricultural Research Station, Guntur, during *kharif* 2010-2011 and 2011-2012 to know the influence of weather on Bt cotton under different dates of sowings (monsoon vagaries) in coastal districts of Andhra Pradesh. Results indicated that the maximum rainfall (534,4 mm) received by crop sown on 2nd FN of July and lowest received crop sown on 1st FN of October. Due to variation in dates of sowings, plant height, monopodia, sympodia, bolls/plant, boll weight, dry matter production and yield of seed cotton were affected greatly due to different dates of sowings. Average plant height (91 cm), monopodia (2) and sympodia (19), bolls/plant (44), boll weight (44g/10 bolls), dry matter production (783 g.m2) and yield (2510 kg) were highest in crop sowing on 2nd FN, of July and were lowest in crop sown on 1st FN of October respectively. Correlation coefficient between growth, yield and its components and agrometeorologyical parameters were calculated and parameters showing statistically significant correlation. Rainfall, mean maximum and minimum temperature and RH has significantly positive correlation on all yield and yield parameters except at monopodial stage but sunshine hr, GDD and HTU increased with delay in sowings and has sown negative correlation.

2.12
Bioefficacy of different herbicides in *Bt* cotton (*Gossypium hirsutum* L)

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A field experiment was conducted during *kharif* 2009 at Anand Agricultural University, Anand to study bioefficacy of different herbicides in *Bt* cotton (*Gossypium hirsutum* L). The experiment was laid out in randomized block design with four replications. The soil of the experimental field was loamy sand in texture, low in available nitrogen, medium in available phosphorus and high in available potassium with

slightly alkaline in reaction. Significantly lower total weed dry weight was recorded at harvest under treatment of hand weeding carried out at 20, 40, 60 and 80 DAS which was *at par* with pre emergence application of pendimethalin @ 1000 g/ha *fb* HW at 30 DAS, quizqlofop ethyl @ 75 g/ha POE *fb* HW at 30 DAS and butachlor @ 1000 g/ha PE *fb* HW at 30 DAS. Among the cultural weed control treatments, significantly lower total weed dry weight was recorded at harvest was observed under hand weeding carried out at 20, 40, 60 and 80 DAS and IC *fb* HW at 30 and 60 DAS as compared to other treatments. The highest weed control efficacy was observed in hand weeding carried out at 20, 40, 60 and 80 DAS followed by pre emergence application of pendimethalin @ 1000 g/ha *fb* HW at 30 DAS, quizqlofop ethyl @ 75 g/ha POE *fb* HW at 30 DAS and butachlor @ 1000 g/ha PE *fb* HW at 30 DAS respectively recorded at 25 and 50 DAS and at harvest. Higher seed cotton yield was recorded under the pre emergence application of pendimethalin @ 1000 g/ha *fb* HW at 30 DAS, which remained *at par* with IC *fb* HW at 30 and 60 DAS, quizqlofop ethyl @ 75 g/ha POE *fb* HW at 30 DAS while the lowest seed cotton yield was observed in weedy check. The highest oil content in cotton seed was noticed under pre emergence application of pendimethalin @ 1000 g/ha *fb* HW at 30 DAS followed by hand weeding carried out at 20, 40, 60 and 80 DAS, paraquat @ 500 g/ha POE as protected spray *fb* HW at 30 DAS, fenoxaprop-p-ethyl @ 75 g/ha POE *fb* HW at 30 DAS and butachlor @ 1000 g/ha PE *fb* HW at 30 DAS.

2.13
Performance of *Bt* cotton under different methods of irrigation in vertisols

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Cotton is one of the most important cash, commercial and fibre yielding crop grown mostly under rainfed conditions in Andhra Pradesh. Variability in rainfall pattern with uneven distribution, soil and improper crop management are adversely affecting the seed cotton yield in the region. Cotton crop is very sensitive to irrigation as excess moisture in its initial growth stages and uncontrolled moisture stress at later stages adversely affect the yield. Under such circumstances economization and proper management of limited available water in rainfed cotton is having paramount importance. The micro irrigation system has the capability of applying sufficient water to meet the evaporative demand of the crop on a daily basis. This promotes maximum growth of the cotton plant while minimizing the stress due to adequate supply of soil moisture through micro irrigation. Keeping this in view, an experiment was planned to evaluate the performance of *Bt* cotton under different methods of irrigation in vertisols at Regional Agricultural Research Station, Guntur, during *kharif* 2011. Growth of the cotton crop in terms of plant height and bolls/plant was maximum in surface drip irrigation and sub surface drip irrigation while comparing with flood irrigation and rainfed cotton. Soil moisture with sub surface drip irrigation was more at different depths compared to surface drip irrigation. Seed cotton yield was maximum (3056 kg/ha) in surface drip system followed by sub surface drip system (2889 kg/ha). Lowest seed cotton yield was recorded under rainfed system (2028 kg/ ha). Considering the cost involved, surface drip system in cotton can be more advantageous and highly economical.

2.14
Influence of high density plant population and fertilizer levels on seed cotton yield of American cotton

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Cotton is the most important commercial and fibre crop of India and plays an important role in Indian economy. Among different manipulations, selection of potential genotypes along with optimum plant stand and ideal fertilization play important role in increasing the productivity of cotton crop. Imbalanced uses of fertilizer may affect the vegetative and reproductive growth resulting decline in seed cotton yield. The variation in yield parameters and their component have been found with fertilizer application under different plant population treatments. So the present study was undertaken to evaluate the high density plant population and fertilizer requirements for achieving high yield potential of American cotton. The field experiment was conducted at Cotton Research Station, Sirsa, during *kharif* 2010 and 2011. The experiment was conducted in split plot design with three replications.Three plant populations namely [67.5 x 30 cm (49383 plant/ha), 67.5 x 22.5 cm (65833 plant /ha), 67.5 x 10 cm (148148 plant /ha) were assigned to main plot and three fertilizer levels [100% RDF, 125% RDF, 150% RDF] in subplot. The mean seed cotton yield during 2010 and 2011 was higher at 67.5 x 10 cm (25.87 q/ha) and 67.5 x 15 cm (24.80 q/ha) as compared to 67.5 x 30 cm (22.43 q/ha). The increase in yield was namely due to increased of plant population. However, bolls/plant and yield/plant were higher in (67.5 x 30 cm). The highest seed cotton yield was recorded with a fertilizer levels at 150 per cent RDF which is statistically *at par* with 125 per cent RDF but significantly higher than 100 per cent RDF. The increased in seed cotton yield was observed 3.0 and 6.3 percent with 125 and 150 per cent RDF, over that of 100 per cent RDF, respectively. The number of boll and yield per plant were recorded higher in fertilizer doses of 150 per cent RDF than 100 per cent RDF.

2.15
Precision farming in cotton at northern Karnataka

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Precision farming is a new technology that adjusts application levels of agriculture inputs to accommodate variations within fields. Precision farming in cotton is taken at Bisnalli village of Haveri district in northern Karnataka on 128 ac of farmer's field. Whole village was considered for adoption of precision farming technique. The land resource consists of black, red and mixed red and black soil. Initially cadastral map of the village was obtained and all the cotton plots were selected by discussing with the cotton growing farmers. Soil samples were collected at 60 m grid (each grid representing 1 ac) in each and every block to know the initial soil fertility status and to know the soil variability. At each grid lat/long positions were

recorded with Garmin eTrex' HC series GPS. The data on pH, EC, N, P, K, Zn, Mn, Fe and Cu were collected and variability for the field and in field variability was assessed. Management zones were formed based on the soil fertility status for major nutrients. The fertilizer levels were calculated based on the SSNM concept for varied target levels (20, 25, 30 and 35 quintals/ha). This enabled the scientists to precisely apply the required nutrients in accurate quantities to the root zone during critical phases of crop growth according to the target yield. Further, the variability in Pests and diseases were observed at 15 days interval from 45 DAS till peak boll development stages. Soil moisture variability was observed through the effect of rainfall and its distribution on soil moisture status in different soil types and their effect on crop growth. Soil variability, pest and disease variability, soil moisture and crop variability was assessed at varied grids and suitable measures were taken to counteract the variability. LISS IV Remote sensing data of the study area was also procured to assess the variability in plant growth through various growth indices. Plant growth parameters and seed cotton yield was also recorded at specified grids and extent of yield achieved was compared. Variability maps for nutrient status for pH, EC, N, P, K, Zn, Mn, Fe and Cu, pest and disease as well as yield maps were generated using GIS techniques. It was possible to achieve the targeted yield through precision farming technique by adopting SSNM concept based on yield target to the extent of 100 per cent at moderate targets (20 to 25 q/ha) and to the extent of 75-85 per cent with higher targets (30-35 q/ha).

2.16
Ascertaining the damage to water soaked *Bt* cotton seed sown by seed drill

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To ascertain this fact, preliminary studies were carried out at Punjab Agricultural University, Regional Research Station, Faridkot during kharif 2011and 2012 to visualize the changes in seed size, volume and weight of *Bt* cotton in the laboratory experiments as well as in field conditions. The study comprised of five treatments *viz.*, control, direct sowing without soaking in water (T_1), sowing seed after soaking in limited water (20 ml) for 1 hr and thrice stirring of seed (T_2), sowing seed after soaking in limited water (20 ml) for 2 hr and thrice stirring of seed (T_3), sowing seed after soaking in 60 ml water for 1 hour (T_4) and sowing seed after soaking in 60 ml water for 2 hours (T_5). The quantity of seed in all treatments was 60 g. The results indicated that an increased in seed weight of 26.1-112.8 per cent during 2011 and 9.62-35.8 per cent during 2012 under varied levels of soaking treatments. Acid delinted *Bt* cotton seed is capable of absorbing water equivalent to 1/3 of its weight within one hr of soaking without any left over water to be drained prior to sowing. There was a progressive enhancement in weight of the soaked seed with increased duration as well as quantity of the water used. When seeds of different treatments sown by seed drill in the field, the highest emergence (80.0 and 70.9 %) was reported with direct sowing of *Bt* seed without soaking in water (T_1) and lowest emergence of 60.3 and 62.3 per cent under T_5. There was a gradual decline in the emergence with prolonged soaking. This might be due to the fact that increased weight and volume of seed in over soaked treatments resulted in more mechanical damage to seed by drill. On the basis of these preliminary studies, it is cleared that seed of *Bt* cotton hybrids got mechanical damage due to over water soaking. Therefore, when good moisture conditions are prevailed in the field, farmers could sow the *Bt* cotton delinted seed, without soaking into water.

2.17
Effect of different spacing and potassium levels on seed cotton yield and economics of *hirsutum* cotton under irrigated conditions

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Field experiment was conducted during three consecutive *kharif* season of 2007 to 2009 at Oil Seeds Farm, Kalyanpur, Kanpur. The objective was to see the effect of different spacings and levels potassium on seed cotton yield and economics of *hirsutum* cotton. Pooled data of three year’s revealed that significantly higher seed cotton yield was obtained with the spacing of 67.5x30 cm (1357 kg/ha) over rest of spacing of 67.5x45 cm (1122 kg /ha) and 100x30 cm (1281 kg/ha) and the difference was to the tune of 21.9 and 6.0 per cent. All the yield attributing character *viz.*, bolls/plant and boll weight (g) were significantly superior with 20 kg/ha potassium application over control. Application of potassium 20 kg/ha recorded significant higher seed cotton yield (1281 kg/ha) by 16 per cent than control (1103 kg/ha) and from *at par* with potassium application of 40 kg /ha (1317 kg/ha). Higher gross return (Rs 38783/ha), net return (Rs 15861/ha) and B: C ratio (1.68) were with the application of potassium 20 kg/ha as compared with no potassium application (Rs 34083/ha), net return (Rs 11441/ha) and B:C ratio(1.50). All the interaction effects were found to be non-significant.

2.18
Performance of *Bt* cotton under different spacings, time of fertilizer application and nutrient levels

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A study was conducted at Research Farm, Department of Agronomy, CCS Haryana Agricultural University, Hisar during *kharif* 2010. Maximum plant height was recorded at closer spacing of 100x 40 cm. Maximum sympods/plant were recorded in wider spacing (100 x 60 cm) which were significantly higher than closer spacing (100 x 40 cm and 100 x50 cm). Seed cotton yield (kg/ha) was highest in closer spacing (100 x 40 cm). Maximum oil content (%) and protein content (%) was recorded in cotton seed in wider spacing (100 x 60 cm) which were significantly higher than closer spacings (100 x 40 cm and 100 x50 cm). Spacing 100 x 40 cm and 100 x 50 cm resulted in higher total cost of cultivation, gross returns and net returns than 100 x 60 cm with 100 per cent and 125 per cent of recommended dose of fertilizers. Benefit: cost ratio was significantly higher with spacing of 100 x 40 cm and 100 x 50 cm with 100 per cent and 125 per cent of recommended dose of fertilizers where application three split doses of N fertilizer.

2.19
Studies on the efficacy of herbicides against weeds of cotton crop

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A field experiment was conducted at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur during *kharif* 2009 and 2010. The objective was into studies 011 the efficacy of herbicides against weeds of cotton crop, The cotton varieties RS 2013 (*hirsutum*) was sown on 18-06-2009 and 24-06-2010 respectively at a row spacing of 60 cm. Soil was sandy loam having 7.6pH. Agronomic practices were adopted as per recommendation of the crop. Eleven treatment combinations were tested in randomized block design with three replications. The results revealed that the application of clethodium (24%EC) @60g.a.i./ha +NIS -AMS produced maximum seed cotton yield of 13.91 and 9.70q/ha during first and second years, respectively. This treatment controled maximum weeds as dry weight of weeds were recorded lowest 5.42 and 7,44g, The weed control efficiency was also highest in this treatment (73.37 and 65.86%) in first and second year. respectively. The maximum net profit of Rs. 23379 and Rs. 62004 was achieved with clethodium (24%EC) @60g.a.i./ha + NIS –AMS in both the years, respectively.

2.20
Effect of split application of N and K to *Bt* cotton under rainfed conditions

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An experiment on split application of fertilizers was conducted at Cotton Research Station, Nanded during 2010-2011 on black cotton soil with low in organic carbon and available N, medium in P_2O_5 and high in K_2O with neutral to slightly alkaline pH to study the effect of split application of N and K_2O on growth, yield and economics of *Bt* cotton under rainfed condition. Treatment consisted of two levels of potassium splits (100% a basal and 50 per cent basal + 50 per cent 4 WAS) as one factor and three levels of nitrogen splits (two, three and four splits) as second factor. Experiment was analyzed in FRBD with four replications. The experiment results revealed that application of potassium in two split (50% basal + 50% 4 WAS) was non significant with (100% basal) application for growth, seed cotton yield and monetary returns. Four splits of nitrogen (20% basal + 30% 4 WAS + 30% 8 WAS + 20% 10 WAS) recorded highest yield contributing characters, seed cotton yield (2198 Kg/ha), GMR (Rs. 84,540/ha), NMR (Rs. 47,915/ha)and B:C ratio (2.31). However, four splits of N was found *on par* with three splits (40% as basal + 30% 4 WAS + 30% 8 WAS) for seed cotton yield, GMR, NMR (2096 kg/ha, Rs. 80,631/ha, Rs. 45,311/ha, respectively) with B:C ratio of 2.28.

2.21
Effect of foliar spray of potassium nitrate on productivity of *Bt* cotton hybrids under sandy loam soils of Haryana

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Bt cotton covered about 90 per cent of total area under cotton, a remarkably high growth in just six years. Production of *Bt* cotton has suffered severely due to late planting of cotton in cotton-wheat rotation, severe incidence of sucking pest, occurrence of wilt, flower drop, not/late opening of bolls and abrupt weather conditions resulted yield loss. The application of foliar nitrogen and potassium to cotton at or near the early bloom stage of growth, when these nutrients are needed most, has gained in popularity in recent years. Keeping in the view, demonstrations on foliar spray of potassium nitrate were conducted. Four foliar sprays of potassium nitrate were done @ 5 kg/ha starting from flowering at 10 days interval on *Bt* cotton hybrids at farmers' field at 25 locations covering an area of one acre at each location in different villages selected randomly of District Fatehabad during *kharif* 2009 and 2010 under Krishi Vigyan Kendra, Fatehabad. Results of the trial revealed that average seed cotton yield was to the tune of 24.5 and 23.9 q/ha in demonstration as compare to 22.9 and 21.8 q/ha in local check which was 6.9 and 9.6 per cent higher that of local check. Return over variable cost was to the tune of 4.6 and 10.9 per cent higher under demonstration over local check during both the years, respectively. Benefit: Cost ratio figured 1.98:1 and 2.71:1 under demonstrations as compared to 1.88:1 and 2.65:1 in local check during 2009 and 2010, respectively.

2.22
Effect of organic and inorganic sources of nutrients on productivity and economics of *desi* cotton under various plant protection measures

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Field experiment was conducted during *kharif* 2004-2005 and 2005-2006 at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola to study the influence of organic and inorganic sources of nutrients on productivity and economics of desi cotton under different plant protection measures. Experiment results revealed that the treatments (FYM @ 10 t/ha and vermicompost @ 2 t/ha being *at par* recorded significantly higher seed cotton yield and GMR/ha in both the years. In pooled analysis treatment FYM @ 10 t/ha recorded significantly greater seed cotton yield (13.75 q/ha) and GMR/ha (Rs. 26204/ha). Treatment seed inoculation with *Azotobacter* + PSB recorded significantly maximum value of NMR and B:C ratio in both the years and in pooled analysis (Rs. 11535/ha and 2.31). Seed cotton yield/ha and economic parameters *viz.,* GMR, NMR and B:C ratio were significantly greater with treatment 50:25:25 kg NPK/ha in both the years and in pooled analysis. Seed cotton yield and GMR ha^{-1} were significantly higher with treatments inorganic and organic plant protections, respectively in both the years. NMR and B.C. ratio were greater with treatment no plant

protection and inorganic plant protection in both the years and in pooled data. Thus, treatment combinations of FYM @ 10 t/ha + 50 :25:25 kg NPK/ha and Vermicompost @ 2 t/ha + 50 :25:25 kg NPK/ha being *at par* registered significantly higher seed cotton yield and GMR/ha in both the years. Treatment combinations of seed inoculation with *Azotobactor* + PSB with 50:25:25 kg NPK/ha recorded significantly maximum NMR/ha and B:C ratio in both the years.

2.23
Effect of differential nutrient levels and their application on Bt cotton

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A field experiment was carried out to assess different levels methods and time of fertilizers application to Bt cotton at Agricultural Research Station, Siraguppa during *kharif* 2005-2006 to 2007-08. Experiment was laid out in a split split plot design consisting of three levels of fertilizer application *viz.*, RDF (75%), RDF (100%) and RDF (125%) as main plots, two methods of fertilizer application viz., N split, PK basal and N, K split & P basal as subplots and three time of fertilizer application *viz.*, Basal (12.5%), 50DAS (16.7%), 80DAS (16.7%) and 100DAS (16.7%), Basal (12.5%) ,25DAS (12.5%), 50DAS (25%) ,75DAS (25%) and 100DAS (25%) and Basal (12.5%), 25DAS (12.5%), 50DAS (50%),75DAS (12.5%) and 100DAS (12.5%)as sub sub plots. Application of RDF (125%) resulted in significantly higher yield (2635 kg/ha) over RDF (75%) (2229 kg/ha), but it was *on par* with application of 100% RDF (2593 kg/ha) in pooled data. Split application of nitrogen, potassium and phosphorus as a basal dose gave significantly higher seed cotton yield in pooled data (2543 kg/ha) over application of nitrogen and potassium as split and phosphorus as a basal (2428 kg/ha). Seed cotton yield (2613 kg/ha) was significantly increased by the application of fertilizer at basal (12.5%), 25 DAS (12.5%), 50 DAS (50%), 75DAS (12.5%) and 100 DAS (12.5%) than other two time fertilizer application. The interaction effects of different levels, time and methods of fertilizer application was found to be non significant.

2.24
Effect of nutrients on physiological disorders and yield of *Bt* cotton (*Gossypium hitsutum* L) under irrigation

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A field experiment was conducted during *kharif*, 2010 at Agricultural College Farm, Raichur to study the effect of macro and soluble micronutrients on physiological disorders and yield of *Bt* cotton under irrigation. The results revealed that at boll formation stage (105 – 125 DAS), application of 125/cent RDF without foliar spray of water soluble micronutrients recorded the highest number of squares dropped per plant

(12.23) whereas, application of 100 per cent RDF with the foliar spray of 0.5 per cent nutriment recorded the lowest (8.07) number of squares dropped/plant. Application of 75, 100 and 125 per cent RDF with water soluble nutrients did not produce significant differences at flowering (85 – 100 DAS) and boll formation stage (105 – 125 DAS) on flowers/plant. At flowering stage (85 – 100 DAS), application of 125 per cent RDF without foliar spray recorded the highest bolls dropped/plant (3.40) whereas, application of 75 per cent RDF with the foliar spray of 10 ppm planofix and 0.5 per cent nutrient recorded the lowest (2.13) bolls dropped/ plant. Application of 125 per cent RDF with the foliar spray of 0.5 per cent tracel micronutrient recorded the highest seed cotton yield (19.88 q/ha) whereas, in absence of foliar nutrition with 100 per cent RDF recorded the lowest seed cotton yield (12.12 q/ha).

2.25
Response of *Bt* cotton to different spacing, growth regulator and nutrient management system

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A field experiment was conducted at Department of Agronomy, Marathwada Krishi Vidyapeeth, Parbhani during *kharif* 2010-2011 and 2011-2012. The experiment was laid out in split plot design and replicated thrice with twenty four treatment combinations comprising, four plant spacings *viz.*, 90 x 60 cm, 120 x 45 cm, 150 x 36 cm and 180 x 30 cm, two growth regulator treatments *viz.*, control and NAA + GA_3 and three fertilizer levels *viz.*, 100:50:50 kg NPK/ha, 150:75:75 kg NPK/ha and 200:100:100 kg NPK/ha. The cotton cultivar Bunny *Bt* (NCS-145) was used for experiment. All growth parameters *i.e.* (plant height, functional leaves, leaf area and dry matter), yield contributing characters (bolls/plant, boll weight and seed cotton yield/plant), seed cotton yield (kg/ha) and net returns were higher with plant geometry 150 x 36 cm than remaining plant spacings. Application of growth regulators NAA + GA_3 recorded maximum yield contributing characters, seed cotton yield (kg/ha) and net returns over control. As regards to nutrient management application of 200:100:100 kg NPK/ha was found most beneficial in respect of growth parameters, yield attributes, seed cotton yield and net returns over lower levels of nutrients. Therefore from present investigation it can be concluded that *Bt* cotton sown at 150 x 36 cm plant geometry with application of 200:100:100 kg NPK/ha to achieve maximum profit during *kharif* season on vertisols.

2.26
Studies on application of nutrient chemicals to ameliorate leaf reddening in *Bt* Cotton

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Leaf reddening in cotton is also known as red leaf disease (*lal patti*). This physiological disorder is an outcome of interaction of location, variety, environmental condition and nitrogen supply. In general, some

of the *hirsutum* varieties and a few inter and intra specific tetraploid hybrids are sensitive and vulnerable to this malady. An experiment was conducted in *Bt* cotton for two years 2010-2011 and 2011-2012 using twelve treatments with different combination of nutrient application and foliar nutrition of major and minor nutrients. *Bt* cotton was grown in RBD design at Agricultural Research Station, Dharwad and evaluated the effectiveness of different agrochemical treatments on reducing the reddening. The two years pooled data showed the treatment T_9 (RDF + 2 spray MgSO4 (0.5%) at 75 and 90 DAS) and T_8 (T_2+ 2 spray of KNO3 (0.5%) at 75 and 90 DAS) showed significantly higher SPAD reading, LAI and rate of photosynthesis compared to control and other treatments. Similarly significantly higher boll weight and more number of bolls was recorded by T_9 fallowed by T_5 (T_2+ 2 foliar spray of urea (2%) and DAP (2%) alternatively at 8 days interval from 60 DAS), while least was observed in T_2(RDF based on soil test values) and control. The range of Leaf reddening was recorded for all the treatment ranging from 1 to 5 scale. The treatment T_9 recorded the least followed by T_8 compare to control. The two years pooled data showed the treatment T_9 (RDF + 2 spray MgSO4 (0.5%) at 75 and 90 DAS) recorded significantly high yield & yield components followed by T5 (RDF + 2 foliar spray urea DAP (2% alternatively) at 8 days interval for 60 days) while least recorded in control and other treatments. This significant high yield and yield components in T_9 was positively supported by phenological and physiological parameters. Overall we found the treatment T_9 found to be better in ameliorating leaf reddening in *Bt* cotton.

2.27
Evaluation of cotton genotypes for drought tolerance under rainfed conditions

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A field experiment was undertaken for three years during *kharif* 2009-2010 to 2011-2012 at Cotton Research Station, Nanded to study the performance of 18 cotton genotypes for water stress tolerance, yield components and physiological parameters under rainfed situation. The genotypes BS 30 followed by ARBH 813, NH 635, NH 615 and Sahana were recorded highest leaf area index, specific leaf weight (%), harvest index (%) and yield components *i.e.*, bolls / plant, boll weight (g), seed cotton yield / plant and seed cotton yield kg/ha. On the basis of physiological parameters the genotypes BS 30, ARBH 813, NH 635, NH 615 and Sahana were found superior for water stress tolerance under rainfed situation which were also found early in maturity.

2.28
Nutrient management in *Bt* cotton under semi arid region of Punjab

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A field experiment was conducted at PAU Regional Station, Bathinda during *kharif* 2009-2010 and 2010-2011 in a randomized block design in three replications with 9 treatments *i.e.* Boron spray (0.1%) at flowering, $ZnSO_4$ spray (0.5%) at flowering, MnSO4 spray (1.0%) at flowering, $MgSO_4$ spray (1%) at flowering, $MgSO_4$ (1%) + $ZnSO_4$ (0.5%) at flowering, $FeSO_4$ (0.5%) at flowering, $FeSO_4$ (0.5%) + $ZnSO_4$ (0.5%) spray at flowering, and Urea (2%) at flowering + DAP (2%) at boll development stage and control. The soil was sandy loam, low in organic carbon, medium in phosphorus and high in potash with pH of 8.4. The results showed that the highest seed cotton yield (35.4 q/ha) was obtained in the $FeSO_4$ (0.5%) applied at the time of flowering of the crop followed by spraying of $FeSO_4$ (0.5%) + $ZnSO_4$ (0.5%) (32.6 q/ha). The lowest seed cotton yield (26.9 q/ha) was obtained in control. The seed cotton yield recorded in $FeSO_4$ (0.5%) was significantly higher than control, boron, $ZnSO_4$ and *at par* with $MnSO_4$, $MgSO_4$, $MgSO_4$ + $ZnSO_4$, $FeSO_4$ + $ZnSO_4$ and urea + DAP spray. The highest seed cotton yield obtained in $FeSO_4$ spray may be due to higher number of bolls/plan and sympods/plant. The higher seed cotton yield recorded in all the treatments where micronutrients were sprayed at the time of flowering of the crop may be due to higher pH of the soil and at higher pH level the availability of various micronutrients gets decreased.

2.29
Integrated use of chemicals and organic amendments to improve cotton productivity using sodic irrigation water

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In south western districts of Punjab, inadequate and erratic supply of canal water is often supplemented with poor quality underground water to sustain the productivity of cotton crop. The continuous and irrational use of such waters deteriorates the soil health which ultimately reduces the yield of cotton crop. *Bt* cotton hybrids having higher yield potential than existing American cotton varieties are being cultivated in an area of approximately 5.5 lakh ha mainly in the cotton belt of Punjab. This region is characterized with light textured alkaline soils alonwith poor quality underground water. Integrated use of chemical and organic amendments as well as irrigation application strategies for poor quality underground waters may help to enhance cotton and water productivity. To study the effects of various chemical and organic amendments on growth, seed cotton yield, soil properties and water expense efficiency of *Bt c*otton irrigated with poor quality water, a long-term field experiment was conducted on sandy loam soil at Punjab Agricultural University Regional Research Station, Bathinda having semi arid climate during *kharif* 2004-2011 in cotton wheat rotation. The experiment consists of nine treatments *viz.* canal water (CW) alone, CW + Zinc + Farm Yard

Manure (FYM) + Gypsum, CW : Tube well water (TW) alternate irrigation (Pre sowing with CW), TW alone, TW+ Zinc, TW + Gypsum, TW + FYM, TW+ Zinc + FYM + Gypsum and CWpsi TW, alongwith planting of cotton in between the ridges and alternate furrow irrigation. The initial physico chemical characteristics of the surface layer (0-15 cm) of soil before the start of the experiment were: texture sandy loam, pH 8.46, EC 0.145 dSm^{-1}, calcium carbonate (4.63%), organic carbon 2.8 g/kg soil, available phosphorus 12.1 kg/ha and available potassium 367 kg/ha. The residual sodium carbonate and electrical conductivity of the tubewell water used was 6.4 meq/L and 2200 µmhos/cm, respectively. The experiment was conducted by following randomized block design with four replications. Initially, the experiment was started using cotton variety and later on switched to Bt cotton hybrids. The pooled mean data over 2004-2011 revealed that the highest seed cotton yield (2500 kg/ha) was obtained in the treatment in which canal water irrigation was supplemented with gypsum, FYM and Zn, which was significantly superior than other treatments except CW treatment, however, difference in yield was statistically *at par* among TW alone, TW+ Zn, planting of cotton in between the ridges (CWpsi-TW) treatments. The difference in seed cotton yield between the treatments where tubewell irrigation was given along with gypsum alone, FYM alone, both gypsum + FYM in combination with Zn proved to be significantly superior than TW alone application. Ancillary plant characteristics like bolls, monopods and sympods/plant were statistically significant among different treatments. In tubewell irrigated treatments, the detrimental effect on soil properties was found to be minimum with the application of gypsum, FYM and Zn. The highest water expense efficiency was recorded in CW+FYM+gypsum+Zn.

2.30
Effect of transgenic cotton on soil biological health under vertisol of central India

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Consequences of transgenic cotton (*Bt* cotton)-based cropping system on soil biological health are not clearly understood. This study was examined the soil biological parameters on major *Bt* and non *Bt* cotton based cropping system, which includes soybean, redgram, wheat and vegetables under vertisol in Nagpur districts of Maharastra. It was observed that *Bt* cotton based cropping system as compare to non *Bt* cotton system had more impact on soil biological and biochemical activities such as soil microbial biomass carbon, soil respiration, dehydrogenase, fluorescein di-acetate hydrolysis, alkaline phosphatase and glomalin protein content followed by cotton redgram, cotton-wheat, cotton-vegetables and cotton-fallow. In general, it was proved that all properties showed its highest activities under *Bt* cotton as compare to non *Bt* cotton based cropping system. Further, soil biological activities were significantly correlated with soil active pools of carbon (water soluble carbon, carbohydrates and microbial biomass carbon). This study clearly indicated that the greater microbial activities in *Bt* cotton based cropping system was due to substantial improvement of soluble phase of carbon through rhizodeposition, root biomass and leaf-fall which acted as source of bioenergy for soil microbes.

2.31
Desi cotton : The worth and unique nature's gift for organic cotton farming

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India ranks second in cotton production and first in the area in the world. This mainly happened due to introduction of *Bt* Cotton. In spite of this rosy picture, as years passed, the shortcomings of Bt cotton surfaced. The sucking pests especially Mealy bugs and jassids have become menace for cotton growers and researchers. The claims made at the time of introduction of *Bt* cotton for safe environment with low cost of cultivation does not hold true anymore. *Desi* cotton have inherent capacity of tolerance to biotic and abiotic stress therefore best bet for minimal use of insecticides and reduced cost of cultivation. They fit well in ecofriendly organic cultivation. Improved varieties of *desi* cotton are observed to be *at par* with *hirsutum v*arieties in respect of seed cotton yield with desired fiber quality. At present textile industry has acute shortage of short and medium staple fibre, therefore the situation can be exploited to the advantage of cultivation for desi cottons as worthy tool for organic cotton farming. Generally, *desi* cotton is grown by small and marginal farmers in poor soils with low care management which results in lower seed cotton production. If *desi* cotton is grown with good management and adequate input seed cotton yield upto 2000 kg/ha can be harvested. Alternatively, *desi* cotton can be exploited for organic cotton cultivation to cater huge demand in international market. In Kutch district of Gujarat state about 1000 farmers had grown successfully desi cotton as organic cotton and get considerable economic return.

2.32
Impact of production technologies on yield and economic perspectives of farmers of Vidarbha Region

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Cotton the "king of the fibre" is a premier cash crop and plays a vital role in the economy of agriculture and industry. Maharashtra has an estimated area of 4 m ha under cotton, of which 97% area is under rainfed cultivation. About 16 lakh ha is under cotton in Vidarbha and most farmers being cotton growers their economy is closely linked to cotton production. Keeping this in view to improve the yield of Bt cotton and the economy of the farmers through the value of kapas and by-products , on-farm trials with different agronomic production technologies were conducted on Bt cotton (bunny Bt) in 60 acres land of Nandura and Loni villages of Yeotmal district during 2008-09 to 2011-12. The different agronomic production technologies included INM + Protective irrigation (PI), INM with 75x75cm, INM with 75x60cm (closer spacing) were demonstrated and compared with Farmers Practice (90x60cm). The Integrated nutrient management technology represents NPK fertilizer dose (90:45:45 N:P_2O_5:K_2O in kg/ha) +10 kg $ZnSO_4$/ha +1ton FYM/ha + PSB@100g/ ha + 2% DAP spray. Thirty farmers were adopted and each component technology was replicated into the

field of 10 farmers. The four years results indicate that farmers using INM + one/two protective irrigation recorded significantly higher yield of 16.62, 21.82, 24.20 and 26.30 q/ha as compared to farmers practice (seed cotton yield of 8.59, 14.88, 10.61 and 10.62 q/ha) in 2008, 2009, 2010 and 2011 respectively. High precipitation during active growth period about (400 mm) and low temperature affected the initiation of fruiting parts in cotton resulting to low yield in 2010 as compared to 2011.Under this program farmers fetched higher net returns of Rs 37152, 43452, 94690, 68820/ha, in the respective years with INM +PI production technology as compared to farmers practice (Rs 15191, 28279, 35067 and 21108/ha). Additional amount of Rs 1000/ha against the sale of cotton stalks and clean cotton picking was also received by the farmers.

CROP PROTECTION AND BIOSAFETY

POSTER PRESENTATION

3.1
Prediction of leaf curl virus disease in cotton (*Gossypium hirsutum* L) by using weather parameters

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Cotton leaf curl virus disease in cotton is the major reason for the decline in production and productivity in North India. The disease is caused by a single stranded circular Gemini virus transmitted by whitefly (*Bemisia tabaci*). The disease generally appears in the month of June on 35-45 days crop and spreads rapidly during July. The hot and humid climate in North India during crop season is conducive for the growth of host and for the spread of disease. To find out the relationship between the disease intensity with weather parameters, the experiment was conducted from 2005-2006 to 2011-2012 crop seasons using susceptible cultivars HS 6 at Cotton Research Area, CCS Haryana Agricultural University, Hisar. The maximum temperature (-0.59), minimum temperature (-0.53), wind speed (-0.69), evaporation (-0.62) and rainfall (-0.11) showed –ve correlation with disease development, whereas, morning relative humidity (0.48), evening relative humidity (0.11), sunshine hr (0.21) and cumulative rainfall (0.79) showed +ve correlation. The optimum range of maximum and minimum temperatures for development of leaf curl disease in cotton was from 32.0 to 37.0°C and 23.0 to 28.0°C, respectively. There was an exponential relationship between disease development and cumulative rainfall (sigmoid growth curve) i.e. the rate of disease development was initially slow till the accumulation of 100 mm rainfall and thereafter disease development increased sharply. The sunshine hours showed a linear relationship with disease indicating that the clear days favored its development. The leaf curl virus disease development in cotton can be explained upto 70 to 72 per cent with the help of weather parameters by multiple regression models.

3.2
Cotton as an colateral host of *Colletotrichum capsici*

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Seven *kharif* crops (cotton, mungbean, cowpea, gram, raddish, tomato and blackgram) and eight weeds (sawank, motha, doob, palpotani, kagroti jangli, surajmukhi, kharjal and Mirch booti) grown in pots in screen house at CCSHAU, Hisar during 2010-2011 (*kharif* season) were inoculated with spore suspension ($3x10^4$ spore/ml) of *Colletotrichum capsici* by pin prick method. These pots were kept in humid chamber for three days. After that pots were removed from the humid chamber and sprayed with distilled waster thrice in a day (morning, noon and evening). Observations were taken 10 days after inoculation and noted the infection on different hosts. The fungus obtained from the anthracnose affected chilli was able to infect

three *kharif* crops (cotton, raddish and blackgram) and four weeds (Sawank, kagroti, kharjal and mirch booti).

3.3
Efficacy of *Trichoderma viride* and *T. harzianum* against foliar diseases of cotton

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In Andhra Pradesh 60 per cent of cotton is cultivated under rainfed conditions by small and marginal farmers. Plant protection costs constitute considerable part of cost of cultivation. Developing low cost technologies will help to reduce the burden of poor tenant farmers. Evaluation of biocontrol agents for management of cotton diseases goes in this direction. During present investigations *Trichoderma viride* and *T. harzianum* were evaluated against foliar diseases of cotton at Regional Agricultural Research Station, Lam, Guntur. Cotton hybrid Bunny *Bt* was raised in plots of 31.5 sq. m with a spacing of 105 x 60 cm. during *kharif* 2010 and 2011. Eight treatments, replicated thrice were imposed in randomized block design. Seed treatment followed by foliar sprays of Tv97, ThKSD (PDBC), Pf-1, Tv-1 (TNAU), Pf-1 (CICR), Pf (ANGRAU), carbendazim and copper oxy chloride at 60, 90 and 120 days after planting were imposed. Data on diseases intensity of bacterial blight, Alternaria leaf spot and rust diseases and yield was recorded. All the treatments significantly reduced rust disease. During *kharif* 2010, Tv97 and ThKSD recorded lowest intensity of rust (18.22% and 18.33%, respectively). Alternaria leaf spot was lowest (9.67%) with Pf (Nagpur) during 2011; Tv97 and ThKSD as well as Pf (TNAU) were statistically *on par* with Pf (Nagpur). Lowest intensity of bacterial blight (10.08%) was recorded with COC followed by Pf (TNAU and Nagpur). Both Tv97 and ThKSD were statistically *on par* in reducing bacterial blight. Pf (ANGRAU) gave maximum yield of 597.88 kg/ha in 2010; Tv97 and ThKSD were *on par*. Pf (TNAU) gave maximum yield of 1375 kg/ha during 2011, other treatments being *on par*. Benefit cost ratio varied from 1.17 to 1.38 in different treatments as against 0.96 in control. Hence it is concluded that Tv97 and ThKSD could be part of integrated disease management in cotton.

3.4
Distribution pattern of cotton leaf curl disease in Haryana

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Upland cotton (*Gossypium hirsutum*) is one of the most important fibre and cash crop of India. Among major cotton growing states, Haryana occupies 6.05 lakh ha.area with productivity 562 kg/ha. in *kharif* 2011. Yet to realize the full productivity, diseases have to be contained within economic threshold level. Cotton suffers from several diseases in which cotton leaf curl disease (CLCuD) may cause up to 46.6 per cent loss in North India. This disease is caused by single stranded circular Gemini virus transmitted by whitefly

(*Bemisia tabaci*) and generally appears in the month of June and later spreads rapidly. In view of the predominance of CLCuD in Haryana, distribution pattern was studied at farmer's field during three consecutive years *i.e. kharif*, 2009, 2010 and 2011 . The data revealed that the pooled average per cent disease intensity (PDI) of three years ranged from 0.0 to 5.3 percent. However, highest per cent disease intensity (5.3) was observed in Hisar district which is closely followed by 5.2 in Fatehabad district. PDI in Sirsa, Jind and Bhiwani was 4.98, 4.55 and 0.9 respectively. In the non traditional cotton growing districts *i.e.* Mohindergarh, Rewari, and Jhajjar, cotton fields were found free from CLCuD except Rohtak where PDI was 0.22. It was also observed that disease intensity was more in 2010 as compared to 2009 and 2011 and highest average PDI (12.6) was recorded in Sirsa distrct in 2010 and Jind district in 2011 (10.02).

3.5
Novel biofilmed biofertilizers for disease control and nutrient management in cotton crop

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India is the world's second biggest cotton grower, with production of 34.25 million bales in the period 2011-2012. One of the major factors influencing cotton production is diseases, especially fungal infections which lead to more than 8-12 per cent losses annually. The fungal diseases such as Fusarium wilt *(F. oxysporum),* Verticillium wilt (*Verticillium dahlia)* are the major factors contributing to reduced crop stand and yields. Although a number of chemical and biological control measures are available, there is a need to develop more effective measures which can withstand the vagaries, especially those related to global climate change. A number of individual microbial biofertilizers are available, but information on their persistence in soil and desirable activity, especially for cotton crop is scanty. Novel biofilmed biofertilizers using *Trichoderma viride,* as a matrix and PGPR (plant growth promoting bacteria - *Azotobacter chrocoocum, Pseudomonas fluorescens* and *Bacillus subtilis*) were developed, which exhibited superior PGPR traits, as compared to individual cultures. Such biofilms were compared for their role *vis a vis* individual partners and dual mixtures, in reducing mortality and improving the growth of *Macrophomina phaseoli* cotton crop. The application of biofilm of *T.viride and B.subtilis* brought about a five six fold lower mortality as compared to the dual and single culture application. Additionally, a two fold enhancement in biomass production and 50 per cent increase in plant height over control were also recorded. The treatments receiving the biofilms also recorded significantly higher microbial biomass carbon and phosphorus content, besides enhanced defense enzyme activity. Our study highlighted the positive interactions of the biofilms with the crop, which led to lower mortality along with enhancement in plant growth and nutrient uptake parameters. Field level assessment of these promising biofilms is being envisaged to provide a biofilmed biofertilizer technology with multiple benefits.

3.6
Sources of resistance against bacterial blight of cotton incited by *Xanthomonas axonopodis* pv. *malvacearum* under natural epiphytotics

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Cotton (*Gossypium* spp.) is one of the important cash, fibre and oilseed crop commonly grown in many parts of India. Bacterial blight disease incited by *Xanthomonas axonopodis* pv. *malvacearum* is a serious threat to successful cultivation of cotton wherever the crop is grown. Considering the socio economic importance of the bacterial blight in cotton cultivation, the most efficient and eco friendly measures like screening for resistant varieties have been advocated for the management of this disease. A total thirty-six cotton genotypes were screened in replicated thrice with randomized block design against bacterial blight disease incited by *Xanthomonas axonopodis* pv. *malvacearum* under natural epiphytotics. Results revealed that 3 genotypes showed moderately resistant, 31 showed moderately susceptible and 2 showed susceptible against bacterial blight of cotton. Disease severity at 60 DAS ranged from 2.42 to 27.5 per cent. The genotype PH 1009 (2.42%) and Paig 29 (2.42%) showed lowest disease severity. Disease severity at 90 DAS ranged from 9.63 to 58.6 per cent. NH 633 (9.63%) showed minimum disease severity followed by PH 1062 (9.91%) and PH 1031 (10.37%). Disease severity at 120 DAS ranged from 11.63 to 68.94 per cent. The lowest PDI was recorded for NH 633 (11.63 %) followed by Paig 265 (13.26 %) and NH 637 (13.55 %). Mean disease severity (PDI) of cotton genotypes ranged from 9.71 to 51.68 per cent.

3.7
Epidemiological studies on leaf curl disease of cotton

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Leaf curl is the major disease of cotton in Sriganganagar district situated in north west part of Rajasthan state in India. Studies were under taken from 2007 – 2010 on disease progress in relation to weather factors and yield losses corresponding to disease index. Leaf curl which appeared during second fortnight of June remained static up to first week of July and its progress remained slow during the entire month. However, in subsequent standard weeks, leaf curl incidence in crop showed rapid increase reaching maximum level of 100 per cent in the end of August. Good crop canopy due to high precipitation, high temperature (35 ^{o}C - 40 ^{o}C) and high humidity (50 – 80%) during vegetative phase of the crop favoured population buildup of white fly vector for longer duration which ultimately enhanced leaf curl. Loss estimation studies revealed significant reduction in number of opened bolls and seed cotton yield at different levels of disease. The

corresponding per cent loss in opened bolls at 1 grade of disease level (0 – 5% PDI) was more than 5 per cent which ultimately enhanced to 65 per cent at 4 grade (50.1 – 100% PDI) of disease level. The estimated losses in seed cotton yield at 1, 2, 3, and 4 grades of disease level were 5.8, 26.8, 49.5 and 69.4 per cent respectively.

3.8
Impact of different agro chemicals on foliar diseases in *Bt* cotton

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Cotton is the most important fibre crop primarily being used in textile industries. In Punjab, the area under cotton cultivation is 5.6 lakh hectares with a production of 19.5 lakh bales and an average productivity of 591.9 kg/ ha. However, the production potential of the crop has not been fully exploited due to several biotic and abiotic factors . The crop suffers from many fungal diseases, of which foliar diseases take a heavy toll. Among the foliar diseases bacterial blight caused by *Xanthomonas axonopodis* pv. *malvacearum* and fungal foliar leaf spots caused by *Alternaria macrospora*, *Myrothecium rordium* and *Cercospora gossypina* are the important ones. In present study, different agro-chemicals have been evaluated against these foliar diseases. For this purpose the experiments were conducted at PAU, Regional Station, Faridkot for two years under natural epiphytotic conditions in 2010-2011 and 2011-2012. In both the years the replicated trials were laid out in a randomized block design. *Bt* hybrid MRC 6304 was sown during 4th week of April at a spacing of 75 X 67.5 cm with a plot size of 27.3 m^2 . Recommended agronomic practices were followed to raise the crop. Six treatments of different agro chemicals namely T_1: Kresoxim methyl (Ergon 44.3%) @ 300ml/ha, T_2: Kresoxim methyl (Ergon 44.3%) @400ml/ha, T_3: Kresoxim methyl (Ergon 44.3%) @500/ha, T_4: Carbendazim @ (0.1%), T_5: Copper oxychloride @ (0.3%) + Streptocycline @ (0.01%) , T_6 : Untreated control were applied thrice at an interval of 15 days starting from the initial appearance of the disease. Final observations on the disease severity were made 10 days after last spray of fungicides adopting 0-4 disease scoring scale. Per cent disease incidence was calculated using wheeler's formula and finally per cent disease control was calculated.. Seed cotton yield was recorded on plot basis in each treatment. The pooled data of two years indicated that all the treatments were effective in checking foliar leaf spots due to bacteria and fungal pathogens compared to control. The highest per cent foliar leaf spots control (50.0%) was recorded in Ergon (44.3%) @400ml/ha. The treatment with Copper oxychloride plus streptocycline gave 48.4 per cent disease control. However, carbendazim exhibited 40.3 per cent disease control . The pooled data on seed cotton yield indicated that maximum yield (25.9 q/ha) was obtained in treatments with Ergon (44.3%) @400ml/ha. So, based on results it was suggested that two or three sprays of the Ergon (44.3%) @400ml/ha were effective to, manage foliar diseases in *Bt* cotton.

3.9
Fungi associated with boll rot of cotton and their control

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Boll rot is an extremely complex problem involving diversified disease symptoms and varying nature of damage at any time from boll set to boll bursting. *Alternaria macrospora, Fusarium moniliforme, Colletotrichum gossypii, Aspergillus niger, Rhizopus stolonifer, Penicillium* spp, *Curvularia lunata*, *Dreschlera gossypii* and *Xanthomonas axonopodis* pv. *malvacearum (Xam)* were found associated with rotted bolls of cotton, from which *A. macrospora, F. moniliforme, C. gossypii and Xam* were found pathogenic. Potato dextrose agar and Richard's media were found good for growth and sporulation of fungal pathogens, while *Xam* growth was excellent on nutrient agar medium. Potassium nitrate and sodium nitrate were good source of nitrogen for profuse growth and sporulation of *A. macrospora, F. moniliforme, C. gossypii,* while glucose and sucrose were good source of carbon for growth and sporulation of the pathogen. The fungicides propiconazole (0.1%), copper oxychloride (0.3%) and streptocycline (100 ppm) were effective against boll rot causing pathogens of cotton, whereas the bioagent *Trichoderma viride* (0.3%) was effective against *A. macrospora, F. moniliforme* and *T. harzianum* against *C. gossypii.*

3.10
Survey, surveillance and cultural characteristics of Alternaria leaf blight of cotton pathogen

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Among the several factors responsible for reduction in yield and quality deterioration of the cotton, diseases are the major one and of these diseases *Alternaria* blight is one of the most important and destructive disease of cotton, inflicting yield losses to the tune of 20-30 per cent. Keeping in view economic importance of cotton and losses incurred by Alternaria blight (*Alternaria macrospora*) disease, present investigations on the aspects *viz.,* survey, isolation of the pathogen, pathogenicity and identification of the pathogen and effect of different culture media on the growth of pathogen were undertaken. The roving survey undertaken in four districts *viz.*, Parbhani, Nanded, Osmanabad, and Beed of Marathwada region revealed that average Alternaria blight incidence ranged from 14.60 to 30.03 per cent. *Bt* cotton crop grown in the district of Nanded was found to be more affected with Alternaria blight (overall incidence 30.03%), followed by the district of Parbhani (25.20%), Beed (21.06%) and Osmanabad (14.60%). In Nanded district, maximum disease incidence (32.60%) was recorded in Degloor tahsil and this was followed by Naigaon tahsil (30.00%) and Nanded tahsil (27.50%). Results revealed that all the 11 culture media tested encouraged better growth of *A. macrospora*. However, potato dextrose agar gave significantly highest radial mycelial growth of 88.18 mm. The second and third best culture media found were Czapek's dox agar (81.28 mm) and Richards agar (79.75 mm). Ashby's manitol agar was found least suitable for the growth of test pathogen (39.92 mm).

3.11
Evaluation of fungicides, botanicals and bioagents against Alternaria leaf blight of cotton

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Among the fungal disease of cotton, Alternaria blight leaf spot caused by *Alternaria macrospora* Zimm is an emerging major foliar disease in Bt cotton and all four cultivated species of cotton are known to suffer from this disease. The disease has been reported to cause 5-35 per cent losses in cotton yield. Considering importance of Alternaria leaf spot disease, the present investigation was (*in vitro)* carried out with an view to find out the efficiency of the fungicides (06) biocontrol agents (06) and botanicals / phytoextracts (06) against *A.macrospora.* Six each of fungicides (@ 500, 1000, 1500 ppm) botanicals (@5, 10, 15%) and biogents were evaluated *in vitro* against *Alternaria macrospora* causing leaf blight/ spot of cotton. All the treatments significantly inhibited mycelial growth of the test fungus over untreated control. Among the fungicides tested, thiram recorded significantly highest mean growth inhibition (90.42%) of the test fungus and this was followed by Captan (82.04%) and mancozeb (79.88%). Out of the botanicals tested, *A sativum* was found most inhibitory and recorded highest mean growth inhibition (37.47%) of the test fungus and this was followed by *A. capa* (34.97%) and *O. sanctum* (32.86%). Among the bioagents evaluated, significantly highest mycelial growth inhibition (63.64%) was recorded with *T. viride* and this was followed by *T. koningii* (62.33%) and *P. fluorescens* (62.27%) both of which were *on par*.

3.12
Cotton waste a viable substrate for oyster mushroom cultivation

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The experimental was conducted to study the cotton waste and its combination with the different agro residues namely wheat straw, paddy straw, brassica straw, sugarcane bagasse, forest litter, summer moong residue , wheat bran and rice bran on wet weight basis (1:5) for spawn run, mushroom primordial appearance, yield and biological efficiency for seasonal cultivation of oyster mushroom, (*Pleurotus sajor caju).* The earliest spawn run (11 days) and mushroom primordial appearance (15 days) was observed in case of cotton waste +wheat straw followed by the cotton waste alone. The yield (up to the fourth flush) and the biological efficiency was also maximum in case of cotton wastes +wheat straw (891.0g/kg substrate) and cotton waste alone (865.0g/kg substrate), respectively. Wheat straw is commonly used for seasonal cultivation of oyster mushroom, but due to its higher cost adds to the codt of cultivation; whereas, easy availability of cotton waste in north India at lesser price, the cotton waste is better suited as the best alternative substrate for the profitable cultivation of oyster mushroom.

3.13
Estimation of losses due to cotton leaf curl disease (CLCuD) in North India

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Cotton leaf curl disease (CLCuD) earlier known as African leaf curl of cotton now has become one of the most important diseases in north Indian states including Haryana which has assumed a serious potential threat comprising on an area of 15 lakh ha. It was reported first time from Nigeria in 1912 and then it spread to all the African countries situated north of equator except Egypt. It severely started affecting cotton in Pakistan from 1987 and brought down the cotton production. The disease has become problematic after it spread in Sriganganagar (north Rajasthan) in 1993. CLCuD caused economical losses to the cotton crop in throughout India. In north India the estimated crop loss due to the disease has caused reduction in yield, boll setting, boll weight and in plant height. Considerable seed cotton yield reduction in Rajasthan (32.9 to 50.3%), Punjab (10.5 to 92.2%) and Haryana (39.4 to 81.4%) states of north India has been reported. The disease incidence and progress depend upon host, pathogen, environment and vector interactions. On a disease rating of 0-4 scale, cotton yield was reduced from 796g to 432.5g/plant from the plants, number of opened balls were from 239.8 (grade 0) to 153.6, reduction in boll numbers and seed cotton was ranged between 49.70 to 82.37 per cent and 60.69 to 81.81 per cent respectively from the plants with highest disease rating. Infection during the seedling stage *i.e.* up to 30 days after sowing yielded merely 98.7g cotton compared to 898.2g from the healthy plants and that was 89.0 per cent reduction in the yield. Early infection of CLCuD on plants also reduced the bolls opening up to 86.26 per cent.

3.14
Studies on insecticidal selectivity towards sucking insect pests in *Bt* cotton

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Cotton, the backbone of the textile industry has the most fragile ecosystem amongst the field crops where approximately 162 insect pests species damage the crop. Economically important insect-pests are leafhoppers, whiteflies, aphids, mealybugs, and bollworms (American bollworm, pink boll worm and spotted boll worm). To contain the sucking insect pests, different insecticides were tested during 2011-2012 at Research Area of Cotton Section. Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar, on RCH 134 BG I. The insecticides were: acephate 75 SP quinalphos 25EC, chlorpyriphos 20 EC, profenofos 50 EC, thiodicarb 75WP, buprofezin (IGR) 25 SC , NSKE 5 per cent and phosalone 35EC. Each treatment was replicated thrice. Before spray the population of leafhoppers varies a from 1.11 to 1.89 in different plots indicating that the pest population distribution in the field was uniform. After 7 days of spray the percent mortality of leafhopper ranged from 23.11 to 73.13. The maximum mortality (73.13%) was observed

in acephate followed by profenofos (67.09%), phosalone (51.58%) and quinalphos (51.71%). The minimum mortality (23.11%) was observed in NSKE followed by thiodicarb (24.36%). Before spray the population of whiteflies varied from 9.00 to 18.10 in different replications indicating uniform distribution of whitefly. After 7 days of spray the maximum (26.88%) mortality of whitefly was observed in treatment NSKE followed by phosalone (25.84%), thiodicarb (17.02%) and buprofezin (16.95%). The minimum (3.49%) mortality was found in acephate followed by profenofos (10.42%). It was concluded from the studies that among the different insecticidal treatments, acephate and profenofos gave the good control of leafhoppers and NSKE and phosalone were most effective against whiteflies.

3.15
Population dynamics of cotton bollworm, *Helicoverpa armigera* (Hübner) on non *Bt* and *Bt* cotton hybrids in Raichur, Karnataka

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Cotton, “White Gold” is an immensely important crop for the sustainable economy of India and the livelihood of Indian farming communities. *Bt* cotton has evoked unprecedented interest and debate among a large section of Indian public. One of the important concerns highlighted was development of resistance in bollworms against *Bt* cotton. Extensive cultivation of *Bt* cotton can impose a continuous and intense selection pressure on bollworms leading to development of resistance against cry toxins also by altered expression of toxing in different parts of *Bt* cotton plants in the scenario of climate change. With this background the present study on population dynamics of *Helicoverpa armigera* were carried out at UAS, Raichur during the year 2008-2010 to assess status of resistance development in this pest. During 2008-2009 and 2009-2010, egg incidence of *H. armigera* on *Bt* and non *Bt* cotton hybrids spread across nearly three months which coincided with peak vegetative stage to boll maturation stage. However, maximum egg incidence was observed during square formation stage to boll maturation stage. Similar trend was followed by *H. armigera* larval population on non *Bt* cotton during the two years of observations with a slight shift in the peak larval population across the seasons and hybrids. In *Bt* cotton no larval population was recorded during 2008-2009. However, a considerable larval population was observed on *Bt* cotton for a short period from boll formation to maturation stage during 2009-2010. Based on the earlier reports and the present studies, it is quite evident that the incidence of *H. armigera* on *Bt* cotton hybrids has been recorded at regular interval since the inception of Bt technology in India. Thus, there is a need for continuous monitoring of *H. armigera* population in cotton ecosystem throughout the country and various IRM strategies should be adopted to mitigate this menace.

3.16
Neonicotinoids in the management of sucking pests of *Bt* Cotton

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Bt cotton has proved its potential against the bollworm complex optimizing the yield thereby. However, sucking pests have emerged out as major threat to *Bt* cotton cultivation from last few years. The seed treatment and foliar application of neo-nicotinoid insecticides have shown promise and hence, an experiment was conducted at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 2008-2009 to study their effects by formulating different modules against sucking pests and their effect on yield in a randomized block design. There were eight treatments replicated thrice. The insecticides were applied as per the treatments and the observations were recorded from 7th day after emergence up to 63 days at an interval of 7 days on number of sucking pests and on yield of seed cotton. The module of seed treatments with spray solutions were found superior to sole seed treatments in reducing the aphid population. The module of seed treatment with thiomethoxam 70 WS @ 4.28 g/kg seed + spray of imidacloprid 17.8 SL @ (0.005%) (30 DAE) + spray of acetamiprid 20 SP @ (0.005%) (45 DAE) had emerged at as most promising combination against aphids. The module of seed treatment with imidacloprid 70 WS @ 7.5 g/kg seed + spray of thiomethoxam 25 WG @ (0.005%) (30 DAE) + spray of acetamiprid 20 SP@ (0.005%) (45 DAE) was found superior in reducing leaf hopper population thiomethoxam 40 WS @ 4.28 g/and imidacloprid 70 WS @ 7.5g/kg. While, both the sole seed treatments were found equally effective in controlling leaf hopper population up to 40 days after germination. However, the module of seed treatment with imidacloprid 70WS @ 7.5 g/kg seed + spray of thiomethoxam 25 WG @ (0.005 %) (30 DAE) + spray of acetamiprid 20 SP @ (0.005%) (45 DAE) was also found to be the best in controlling thrips population. The sole seed treatment both thiomethoxam 70 WS @ 4.28 g /kg seed and imidacloprid 70 WS @ 7.5 g/kg seed proved effective in checking thrips population up to 30 days after germination. In case of whiteflies, non significant differences amongst the treatments were recorded. This might be due to the late appearance of whiteflies on cotton. The treatment of seed treatment with imidacloprid 70 WS @ 7.5 g/kg seed + spray of thiomethoxam 25 WG @ (0.005%) (30 DAE) + spray of acetamiprid 20 SP @ (0.005%) (45 DAE) recorded higher yield of seed cotton, compared to after treatments. Thus, considering the effectiveness against sucking pests and for getting higher yield, the significantly superior insecticidal schedule observed in RCH 2 *Bt* cotton was seed treatment of imidacloprid 70 WS + spray of thiomethoxam 25 WG (30 DAE) + spray of acetamiprid 20 SP (45 DAE).

3.17
Validation and promotion of IPM module in *Bt* cotton acosystem through FLDs

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After introduction of bollgard technology, the change in pest population dynamics in *Bt* cotton was experienced throught out the country. Reliance on pesticides has created insecticide resistance to pests and destruction of useful fauna and flora. Therefore, for the creation of visible impact of IPM,with the objectives of increased productivity, healthier environment and economic profitability, cohesive offorta of different stakeholders like AICCIP, SAU's, State Agriculture Department and farmers are required. One of the important tools of transfer of technology is front line demonstration (FLD).Therefore, a farmer driven programme was put in operation for the validation and promotion of IPM module in different *Bt* cotton ecosystems during 2009-10 among 50 farmers of adjoining villages of Nanded, Parbhani, Hingoli and Beed districts. The IPM module consisting of sowing of border crop of maize + cowpea + marigold + castor as a trap crop, spraying of NSKE (5%) (once at 105 DAS), release of *Trichogramma* (Once at 115 DAS), spraying of insecticides as per ETL, use of yellow sticky traps @10-12/ha for the management of whitefly and monitoring of pest population through pheromone traps etc. was demonstrated. The IPM kit containing maize seed (600g), cowpea (130g), marigold (3.20g), castor seed (60g), *Verticillium lecani* 1.15 WP (2 kg), *Azadirachtin* 3000 ppm (2l), *Spodoptera* lures (10), *Helicoverpa* lures (10) and *Pectinophora* lures (10) was distributed to each farmer for effective demonstration of the module. Regular visits were made by the scientists to demonstration plots and trainings were also given to the farmers. As a result of demonstrations, farmers considerably reduced 4 to 6 numbers of sprays with successful insect pest management which resulted in higher yields ranging from 11.75 to 35.32 q/ha. The study has increased the knowledge level of the cotton growers on IPM technology.

3.18
Efficacy of fipronil 80 WG a new formulation against cotton thrips

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The introduction of *Bt* cotton in India has led to phenomenal increase in cotton productivity by reducing the bollworm complex to the larger extent but at the same time they are susceptible to most of the sucking pests *viz.*, thrips (*Thrips tabaci* Linnman), leafhoppers (*Amrasca devastans* Ishida), aphids (*Aphis gossypii* Glover), whitefly (*Bemesia tabaci* Gennadius) and dusky cotton bug (*Oxycarenus hyalinipennis* Costa). One of the reasons for the attainment of minor pests to major status may be decline in usage of broad spectrum insecticides and also done this the introduction of neonicotinoids which have got specific mode of action and a narrow range of target pests. In this regard a new formulation of fipronil 80 WG was evaluated against cotton thrips, *T. tabaci.* during 2010-2011 and 2011-2012 *kharif* seasons at Main Agricultural Research Station, Raichur. Experiment was laid out in randomized block design with *Bt* cotton hybrid RCH 2*Bt.* On ten days after spary fipronil 80 WG @ 60 g.a i/ha recorded 0.26 thrips/leaf which was *at par* with fipronil 80

WG @ 50 g.a i/ha and the standard check fipronil 5 SC @ 50 g.a i/ha recording 0.38 and 0.72 thrips per leaf, respectively. Fipronil 80 WG @ 40 g a i/ha recorded 1.24 thrips/leaf and it was *at par* with diafenthurion 50 WP @ 300 g a i/ha and imidacloprid 17.8 SL @ 25 g a i/ha which recorded 1.62 and 1.98 thrips/leaf, respectively.

3.19
Management of mealybug, *Phenacoccus solenopsis* Tinsley on cotton

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Field experiment was conducted during 2009-2010 and 2010-2011 to evaluate the efficacy of insecticides and biorationals against *Phenacoccus solenopsis* on *Bt* cotton NCS 145 (Bunny) at Main Agricultural Research Station, Raichur. Profenophos 50 EC @ 2000 ml/ha and buprofezin 25 SC @ 1500 ml/ha were effective in reducing the mealy bug population on cotton. On 14th day after spray, lowest mealybug population of 20.58% in application was recorded buprofezin 25 SC @ 1500 ml/ha which was *on par* with its lower dosage @ 1000 ml/ha and both the treatments were significantly superior to rest of the treatments. This was followed by on cotton receiving profenophos 50 EC @ 2000 ml/ha which recorded 31.45 mealybugs/10 cm apical shoot and was *on par* with its lower dosage @ 1500 ml/ha. There was considerable increase in the population of mealy bug on 14th day in all the treatments except buprofezin 25 SC at both the dosages during both the years. No receiving those two treatments recorded significantly maximum seed cotton yield with higher net returns in both the seasons of study.

3.20
Prediction of favourable time for the multiplication of major insect pests in cotton

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Cotton, the commercial crop is the backbone of the textile industry as it employs vast majority of population directly or indirectly and earns the foreign exchange too. Cotton has been devasted by approximately 162 insect-pests species and economically important insect pests are leafhoppers, whitefly, aphids, mealy bugs, and bollworms (American bollworm, pink boll worm and spotted boll worm). The studies were conducted at CCS Haryana Agricultural University, Hisar. Observations on different insect pests were recorded weekly. The sucking insect pests population started their build up from 21st standard week and continued till 42nd standard week in cotton. The activity of leafhopper nymphs, whitefly adults and bollworm infestation in green fruiting bodies started from 21st standard week (4th week of May) to 42nd standard week (3rd week of October) and 26th standard week (5th week of June) to 42nd standard week (3rd week of October). The peak activity of leafhopper nymphs (3.0 leafhoppers/3 leaves to 6.4 leafhoppers /3 leaves) and whitefly adults

(3.0 whiteflies to 6.7 whiteflies/ 3 leaves) on cotton was from 26th standard week (5th week of June) to 36th standard week (2nd week of September) and 26th standard week (5th week of June) to 37th standard week (3rd week of September), while per cent peak activity of bollworm (5.4 to 6.4) was from 29th standard week (4th week of July) to 39th standard week (5th week of September), respectively. The favourable weather conditions for build up of the pest population were 34.7° C to 32.1° C (max. temp.) and 25.7 ° C to 21.7° C (min. temp.), 34.7° C to 34.2° C (max. temp.) and 25.7° C to 18.3° C (min. temp.) and 34.7° C to 33.4° C (max. temp.) and 24.5° C to 16.7° C min. temp. respectively.

3.21
Relative performance of different sprayers for the control of insect pests of cotton in Haryana

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Efficiency of commonly used sprayers namely, hydraulic knapsack manual operated HI- TECH sprayer (KSHT), hydraulic knapsack manual operated sprayer (KS), power operated knapsack sprayer cum-mist blower (PS) and controlled droplet applicator (CDA) has been evaluated against insect pests of cotton (cv.H 777). Spray volume of 375-750 l with KSHT, KS, 75-150 l with and PS and 2 to 4 l/ha with CDA depending upon crop biomass was used. Phosphamidon 85 WSC @ 200 g a.i and oxydemeton- methyl 25EC @ 250 g a.i/ha (I and II spray) were applied against sucking Pests during vegetative crop growth phase. Whereas, monocrotophos 36 WSC@ 500g a.i and fenvalerate 20EC @ 50g a.i/ha (III & IV sprays) were applied during reproductive phase against bollworm. PS was found to be superior over other sprayers and recorded minimum leaf hopper (0.90 nymph/leaf) and whitefly (1.20 adult /leaf) population during whole cropping period. During reproductive phase also PS recorded lowest bollworm damage in shed fruiting bodies (14.25%) and lower bollworm damage in open bolls both on boll (14.1%) as well as loculi basis (6.5%). Maximum yield of seed cotton (14.6q/ha) was recorded in PS treatments as compared to the rest of the sprayers. The KSHT and KS were at par with each others, whereas CDA was poorest in controlling bollworm infestation and consequently lowest seed yield was in comparison with all other sprayer.

3.22
Changing scenario of pink bollworm, *Pectinophora gossypiella* (Saunders) incidence on cotton in India

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Pheromone traps generally catch target male pest species even when population levels are very low and can therefore be used qualitatively to provide an early warning of pest incidence. Seasonal incidence of pink bollworm, *Pectinophora gossypiella* (Saunders) was largely influenced by the weather factors and its

activity has been successfully monitored by pheromone traps across country where it occurs and this helps to develop effective management strategies Present study reports the incidence of pink bollworm observed in six locations (Sriganganagar, Faridkot, Surat ,Rahuri ,Guntur and Dharwad) across India during 2006-2007 to 2011-2012. Using the data recorded by the AICCIP centers an attempt has been made to correlate moth activity, larval incidence and weather parameters. Peak moth activity was recorded between 38 (18-24 September) standard week to 42 (16-22 October) standard week in Sriganganagar and 39 (25th September 1st October) standard week to 42 (16-22 October) standard week in Faridkot and 50 (11-17 December) standard week to 3rd (15-20 January) standard week in Surat, and 39 (25th September-1st October) standard week to 47 (20-26 November) standard week in Rahuri and 49 (4-10 December) standard week to 4th (21-26 January) standard week in Guntur and 49 (4-10 December) standard week to 3rd (15-20 January) standard week in Dharwad. The peak larval incidence was observed between 38 standard week to 42 standard week in Sriganganagr and 42 standard week to 44 standard week in Faridkot and 52 standard week to 4th standard week in Surat and 41 standard week to 47 standard week in Rahuri and 50 standard week to 4th standard week in Guntur and 47 standard week to 4 standard week in Dharwad. The data recorded during the years of 2006-2007 ,2009-2010, 2010-2011 and 2011-2012 were from non *Bt* cotton (genotypes of RCH 134 *Bt* and HS 06 non *Bt* from Sriganganagr and Faridkot,RCH2 *Bt* and DCH 32 from Surat and Rahuri and Bunny *Bt* and DCH 32 from Guntur and Dharwad) while the data recorded during the years 2007-2008 to 2008-2009 were from *Bt* cotton. The paper attempts to present the correlation of weather data to the moth activity and subsequently to larval incidence.

3.23
Economic viability of drip irrigation in *Bt* cotton and its impact on insect-pests

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Cotton is one of the most extensively cultivated commercial and cash crops of India. It plays a dominant role in industrial and agricultural economy of the country. Cotton production in the country has more than doubled due to the use of *Bt* cotton. Drip irrigation is becoming more popular now a days particularly in arid areas or the areas where water is in limited quantity. It is the most efficient method and have shown good results in terms of saving of water. Besides saving water, it also increases productivity of crops and reduces the infestation of insect pests and diseases as humidity of crop canopy remains lower in drip irrigated crop as compared to flood irrigated. Keeping in view of the above facts, the study was carried out in Sirsa district of Haryana State. *Bt* cotton hybrid (Bio Seeds 6488 BG II) was grown at Paniwala Mota village in two plots (one acre each for drip irrigation and flood irrigation). Spraying of insecticides was made on economic threshold basis and as per package of practices in both plots (drip and flood irrigation). Monitoring was done for population of sucking pests and natural enemies during the crop season. The data revealed that crop grown with drip irrigation had compartively less infestation of sucking pests as compared to flood irrigation. The impact of drip irrigation resulted in 20.0 per cent reduction in number of sprays (for pest control) in comparison with crop grown under flood irrigation system. Spray cost (₹/acre) and cost of cultivation excluding picking and transport were higher in flood irrigation (₹ 1225 and ₹ 10240), respectively as compared to drip irrigation (₹ 990 and ₹8050). Reduction in cost of spraying in drip irrigation was 19.1 per cent and reduction in cost of cultivation was 21.4 per cent. Net profit was also higher in drip irrigation (₹

11690/ac) than flood irrigation. Population of natural enemies per plant (*Chrysoperla*, spiders and coccinellids) was higher in drip irrigation (1.10, 2.42 and 0.89), respectively than flood irrigation (0.99, 2.25 and 0.78). Population of sucking pests in drip irrigated crop was above economic threshold in 2nd fortnight of July while it was above economic threshold in first fortnight of July in flood irrigated crop. Yield of seed cotton figured 12.05 q/ac in drip irrigation as compared to 9.85 q/ac in flood irrigation.

3.24
Screening of newly developed cotton genotypes against key pests of cotton

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To identify resistant/tolerant American and Deshi cotton genotypes against leafhoppers, whiteflies and bollworms 18 newly developed cotton genotypes alongwith 5 checks were screened at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 2011-2012.. The results revealed that 14 genotypes were found resistant (GI) and 9 tolerant (GII) to leafhoppers whereas all the genotypes recorded below ETL population of whiteflies including checks. Lowest open boll damage (5.85 %) was recorded in CMS based *hirsutum* hybrid CAHH 2018 and it was *on par* with other hybrids *viz.*, CAHH 225, AKH 2006-1, CAHH 211 and AHH 0808. The lowest loculi damage (1.68%) was also in CAHH 2018. Out of 18 newly genotypes 10 viz., CAHH 941, AKH 9916, AHH 814, AKH 0205, AHH 0807, CAHH 2018, CAHH 225, AHH 0808, CAHH 211 and AKH 28-2-2 exhibited multiple tolerance against key pests of cotton. These genotypes can be utilized in further breeding programme to develop pest resistant cultivar.

3.25
Impact of integrated pest management strategies on pest complex and economics in *Bt* cotton

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Cotton (*Gossypium spp.*) is the most important commercial crop in India and plays a vital role in agricultural, industrial, social and monetary affairs of the country. The insect-pests are one of the major constraints in achieving optimum yield potential. The insect-pest complex of cotton crop has undergone a tremendous change owing to many reasons, *viz.*, adoption of *Bt* cotton, change in ecological scenario, use of unrecommended insecticides, excessive use of inputs like fertilizers and insecticides at over/under dosages, mixtures of synthetic pyrethroids with other conventional insecticides and faulty spray technology etc. Therefore, IPM strategies of cotton were implemented at farmer’s fields during 2007 to 2009 crop seasons to control insect-pests of *Bt.* cotton village level in Sirsa district (Haryana). Three villages from Sirsa district namely Panihari, Bharokhan and Nuhianwali were selected for adoption of IPM strategies in *Bt*

cotton during the year 2007, 2008 and 2009 crop seasons, respectively. An area of 25 ha was covered under this programme in every crop season involving 66 farmers. *Bt* cotton was grown as per package of practices. An area adjoining IPM programme was kept under observations and this constituted the non IPM programme. IPM strategies included no spray upto first week of July, use of recommended insecticides on economic threshold basis, use of *neem* based pesticide and eradication of weeds for the management of mealybug. The impact of adoption of IPM strategies resulted in 37.5 per cent reduction in number of sprays in IPM in comparasion with non IPM programme. Removal of congress grass and other weeds was found effective to manage the mealybug. Population of natural enemies per plant (*Chrysoperla*, spiders and coccinellids) was higher in IPM programme (1.14, 2.54 and 0.91), respectively than in non IPM programme (0.93, 2.34 and 0.74). Spray cost (₹/ha) and cost of cultivation (₹/ha) were higher in non IPM programme (5150 and 25466), respectively, as compared to IPM programme (3333 and 24583). Benefit cost ratio in IPM programme was 1:2.87 as compared to 1:2.49 in non IPM programme. Net profit was also higher in IPM (₹ 45201/ha) than non IPM (₹ 38001/ha).

3.26
Life tables of *Helicoverpa armigera* (Hubner) on non *Bt* cotton

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Helicoverpa armigera (Hubner) is a major insect pest during last decade on non *Bt* cotton under rainfed conditions of central India, which causes of quantitative and qualitative losses in cotton. The multiplication of *H. armigera* at a faster rate without significant adverse effect from natural mortality factors is responsible for its high generation survival. Hence, an attempt had been made to study the population fluctuations through life tables for identifying vital clues of population changes. For determining mortality factors of *H. armigera*, different life stages were collected from an unsprayed field of non Bt cotton and reared under laboratory condition. The absolute population/ac was computed for preparing the life table on cotton. Also, life tables for field collected and laboratory cultured egg population of *H. armigera* were studied on cotton and artificial diet separately. The observations were recorded during each developmental stage for mortality, survival and key mortality factors. The generation survival was recorded for each rearing host. Life table on absolute population of field collected life stages revealed that early instar (I to III) larvae were found susceptible to the maximum (35.81%) mortality them pre pupal larvae (17.80%) and late instar larvae (14.49%). *Eriborus argenteopilosus*, *Bracon* sp., *Campoletis chlorideae* and *Chelonus* sp. parasitized the early instar larvae to an extent of 7.67, 5.63, 3.50 and 3.07 per cent, respectively. Besides, HaNPV and *Metarrhizium anisopliae* disease also contributed to early larval reduction. In late instar and pre-pupal larvae, Tachinid fly acts as major biotic mortality factor recording 6.34 and 7.63 per cent parasitization, respectively. Pupal stage showed highest mortality compared other stages, where Tachinid fly caused 15.47 per cent parasitization. The life table prepared on cotton field and laboratory cultured egg population revealed maximum mortality of 15.81 and 12.50 per cent in first instar larvae, respectively, followed by egg stage. The generation survival of *H. armigera* in field collected life stages was less than cotton field and laboratory obtained eggs population indicating major influence of parasitoids under field condition and non persistence of egg or egg larval parasitoids in field collected eggs. The age-specific key mortality indicated that first instar larvae were found more vulnerable, recorded high 'k' value on cotton and egg stage on artificial diet.

3.27
Studies on feeding potential of *Cryptolaemus montrouzieri* Mulsant on *Phenacoccus solenopsis* Tinsley

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The study on predatory potential of the predator, *Cryptolaemus montrouzieri* Mulsant revealed that both the stages (adults and grubs), feed extensively on egg, nymph (2nd instar) and adult stages of the mealybug, *Phenacoccus. solenopsis*. But the grubs (larvae) were more voracious feeders. A single grub of the predator consumed minimum of 727 eggs and maximum of 764 eggs with an average of 746 eggs of the cotton mealybug. A pair of adult (female and male) of the predatory beetle consumed 7761 to 7923 eggs with an average of 7847 eggs. A female consumed more eggs (4326) than a male (3520 eggs). Further, it was found that when the grubs of the predator fed on the nymphal instar (2nd) of the cotton mealybug, a single grub consumed 218 nymphs and a adult consumed 189 nymphs for its development. About 17 adult female mealybugs were required to complete the development of adult stage of the predator.

3.28
Evaluation of new chemistry molecules against whitefly (*Bemisia tabaci*) and leafhopper (*Amrasca bigutulla bigutulla*) on cotton

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With the introduction of *B*t cotton, the problem of bollworm complex was highly reduced but the incidences of sucking pests *viz.*, whitefly (*B.Tabaci*), jassid (*A. bigutulla)*, thrips (*Scirtothrips dorsalis*) and mealybug (*Phenacocus solenopsis*) become a serious pest problem in cotton. In Punjab, few insecticides are recommended to control the whitefly and jassid population. So the efficacy of new brands, Sutathion (Triazophos 40 EC) @600ml/ac against whitefly and Dotara, Actara (Thiamethoxam 25 WG) @40g/ac against jassid along with control were investigated in a replicated trial on cotton variety LH 2076 at PAU, Regional Research Station, Bathinda. The results revealed that pretreatment population of whitefly in all the three treatments was non-significant and ranged from 11.5 to 14.5 adults /leave. After 3 days of spray, Sutathion found highly effective in controlling the whitefly population. The whitefly population (7.00 adults/ leave) was below Economic Threshold Level (ETL) up to 10 days of spray and after that it increased to 10 adults /leave after 14 days of spray. In case of jassid, population was non significant in all the three treatments before spray. After 3 days of spray, Dotara showed the maximum (3.50 adults/ leave) population control followed by Actara. Doatara and Actara managed the population below economic threshold up to 10 days after spray, however, population of jassid increased after 14 days of spray. So the results of the present study showed that Sutathion @600ml/ac provides good control of whitefly and Dotara @40g/ac of jassid up to 14 days.

3.29
Efficacy of Spiromesifen 240 SC (Oberon) against *Bemisia tabaci* (Gennadius) in cotton

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Cotton (*Gossypium* spp) is the most important commercial crop in India and plays a vital role in agricultural, industrial, social and monetary affairs of the country. The insect pests are a major constraint in achieving high cotton productivity. More than 130 species of arthropods including 54 pestiferous species harbour cotton crop right from sowing to maturity. With the introduction of *Bt* cotton in Punjab, whitefly, *Bemisia tabaci* emerge as a major pest of the crop. Therefore, experiments were conducted at Krishi Vigyan Kendra, Mansa and Regional Station, Bathinda to determine efficacy of Spiromesifen 240 SC (Oberon) @ 500ml/ha for the control of *B. tabaci* on *Gossypium hirsutum* during 2010 along with the Triazophos 40EC @ 1500ml/ha (recommended by PAU) and Acetamprid 25EC @250g/ha (used by farmers in the state) to combat this pest. Applications of insecticides were done, when the population of whitefly reaches Economic Threshold Level (ETL) on cotton. Observation on the whitefly population were recorded from three leaves (one from top and two from the middle part of the plant) before spray, 3, 7, 10 and 14 days after spray (DAS) in all the treatments. Pooled analysis of results from two locations revealed that after three days of spray, per cent reduction of whitefly population was highest in the Acetamprid (73.50%), whereas efficacy of Spiromesifen and Triazophos was 44.04 and 68.75 per cent, respectively. But the trend was reversed after 7 and 10 days after spray as compared to 3DAS, in these days the maximum reduction in whitefly population was observed in spiromesifen (71.28 and 78.20%, respectively) and triazophos (77.36 and 65.13%, respectively) which were *at par* with each other and significantly better than Acetamiprid in managing the pest. Moreover the population reduction of the Spiromesifen and triazophos decreases on 14DAS but relatively much higher than the reduction achieved by acetamiprid (22.6%). This study suggests that although acetamiprid gave knock down effect of this pest up to third day after spray but lack persistence as in case of spiromesifen and triazophos and provides control of whitefly population up to 14DAS. It can also be concluded from study that spiromesifen also use alternatively for managing the whitefly with triazophos after 14 days interval and acetamiprid should be avoided to spray due to its low persistence.

3.30
Variation in toxicity levels of new chemistries to *Amrasca biguttula biguttula* (Ishida) in exposed and unexposed field populations.

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Studies on the toxicity levels of new insecticides *viz.,* BY-I, acephate, thiomethaxam and confidor compared with conventional insecticide monocrotophos through laboratory bioassay was under taken against exposed and unexposed filed population of third instar nymphs of *Amrasca biguttula biguttula* (Ishida) on cotton using modified leaf dip method. The LC_{50} values (ppm) varied with different insecticides and also with respect to locations. Among all the insecticides BY-I was more toxic and showed lower LC_{50} values of 0.01, 0.02 and 0.01, 0.01 ppm in unexposed and exposed populations of raichur and bellary locations, respectively compared to other insecticides and this was followed by confidor which recorded toxicity of 0.29 and 0.30 in exposed population of two locations and unexposed population recorded 0.15, 0.17 ppm respectively and this low LC_{50} indicates higher toxicity and is can be used for the populations which have developed resistance in filed.

3.31
Performance of different *Bt* cotton hybrids with respect to sucking pests and diseases under North Indian conditions

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The introduction of Bt-cotton has led to sharp increase in the cotton productivity from 284 kg lint/ ha in 2004-05 (year before the introduction of Bt cotton) to 672 kg lint/ ha in 2006-07 (year after the introduction of Bt cotton in Punjab. The huge hike may be attributed to the protection provided by the Bt-cotton towards the bollworm complex and superior quality of hybrids having very high yield potential. During the year of introduction, six Bt-cotton hybrids were approved by the GEAC (Genetic Engineering Approval Committee) among which the RCH134 Bt was the most popular, high yielding and covered about 60-90 percent area steadily increasing from 2005 to 2010. However the productivity trend of cotton did not follow the speculated increasing trend 2007 onwards with productivity coming down to 583 kg lint/ ha during 2007-08. The cause was primarily attributed to outbreak of mealybug *Phenococcus solenopsis*, which was later completely eradicated or managed by massive campaigns started by the state and central government; however no improvement in productivity was observed which further declined to 474 kg lint/ ha in 2009-10 and stabilized at 513 kg lint/ ha during 2011-12. One of the major causes to the fluctuating productivity may be the multiplicity of

the Bt cotton hybrids which have increased from six in the year of introduction to 279 in 2011-12. The number is adding at a very high speed and may go beyond 500 within a couple of years. This has created confusion among the farmers to select a suitable high yielding hybrid for their fields. Keeping in view the problems, 130 Bt-cotton hybrids representing different events approved for the North-zone were evaluated at four different locations, Sirsa and Hissar (Haryana), Faridkot (Punjab) and Sriganganagar (Rajasthan) from 2008-09 to 2010-11 against their reaction towards various insect-pests (leaf hopper: *Amrasca biguttula biguttula*; whitefly: *Bemisia tabaci*; thrips: *Thrips tabaci*) and diseases (cotton leaf curl disease (CLCuD), bacterial blight, and fungal foliar leaf spots). Based on the performance thirty promising hybrids from three years study were again evaluated in 2011-12 at all the four locations to shortlist at least 15 promising hybrids most suited under North Indian conditions The results revealed that transgenic Bt-cotton did not afford complete protection to sucking pest and disease of cotton in general, however they exhibit varying degree of reaction to both the insects and diseases. The Bt cotton hybrids comparatively tolerant to sucking pests were MRC 7017 BG II, MRC 7031 BG II, NCEH 6 Fusion Bt, NCEH 31 Fusion Bt, RCH 605 BG II, Sakthi 9 Bt, SP 7007 BG I, SP 7010 BG II and SWCH 4711 BG II. Only few hybrids RCH 308 Bt, RCH 569 BGII, VBCH 1008 mist and MRC 7361 were found moderately resistant against CLCuD. The top yielders were MRC 7361, VICH 309 BG II, Ankur 3028 BG II, Sakthi-9 Bt, RCH 877 BG II, RCH 569 BG II, NCEH 31 (Fusion Bt), SP 7007 BG I, NCS 855 BG II, RCH 605 BG II, SP-7007 Bt, RCH-134 BG-II and Bioseed 6317 Bt.

3.32
New chemistry for the management of sucking insect pests of cotton in irrigated cotton

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Cotton (*Gossypium* sp.), being the most important commercial crop plays a vital role in social and monetary affairs of the India. Cotton ecosystem harbours about 162 insect species, of which 9 are of utmost importance inflicting significant losses in yield. The monetary value of yield losses due to insect pests has been estimated to be Rs. 2,87,600/- million annually (Dhaliwal *et al* 2004). The insect pest complex of cotton crop broadly grouped into three categories, viz. sucking pests, foliage feeders and bollworms cause damage to various plant parts at different growth stages through out the cropping season in the Punjab. The extent of losses caused by sucking pests, bollworms and both sucking pests as well as bollworms have been recorded up to 12, 44 and 52 per cent, respectively on *hirsutum* cotton and 47 per cent due to bollworms alone on *arboreum* cotton (Dhawan *et al* 1988). In the absence of effective genetic resistance against these pests especially bollworms, farmers solely relied on insecticides for their effective management. Cotton accounts for around 50 per cent of pesticide consumption in the country, despite being grown on area of 5 percent of total cropped area. However, there has been reduction in pesticide load ever since transgenic cotton has been commercialized in Punjab. The insect pest complex of cotton crop in Punjab has undergone a tremendous change owing to many reasons, viz. increase in area under upland cotton replacing the Asiatic cotton, change in ecological conditions, cultivation of large number of cotton cultivars with different varietal reaction to insect pests, unrecommended insecticides, excessive use of inputs like fertilizers and insecticides at over/under dosages, mixtures of synthetic pyrethroids with other conventional insecticides, faulty spray technology etc. *Bt* cotton, dominating in cultivation is damaged by a block of sap feeders like, leaf hopper (*Amrasca biguttula biguttula*), whitefly (*Bemisia tabaci*), mealybug (*Phenacoccus solenopsis*) and

thrips (*Thrips tabaci*). The efficacies of various new insecticides like flonicamid (Ulala 50WS) @ 50, 75 and 100 g a.i./ha and tolfenpyrad (PII-405 15 EC) @ 100, 125 and 150 g a.i./ha against cotton jassid, pyriproxyfen (Pyriproxyfen 10 EC) @ 100, 125 and 150 g a.i./ha and spiromesifen 240 (Oberon 240SC) @ 96, 120 and 144 g a.i./ha against whitefly , sulfoxaflor 24 SC **w**as evaluated @ 60, 75, 90 and 105 g a.i/ha against mealy bug, fipronil (Jump 80 WG) @ 40, 50 and 60 g a.i/ha against thrips alogwith the neonicotinoids like thiomethoxam (Actara 25 WG) @ 25 g a.i./ha, Imidacloprid (Confidor 17.8 SL) @ 25 g a.i./ha for the control of various sucking insect pests of cotton at Entomological Research Farm, PAU, Ludhiana during the 2009 to 2011 in different set of experiments. All the experiments were in randomized block design with 3-4 replication. Cotton crop was sprayed once with knapsack sprayer. The data was recoreded before spray and 3, 7, and 10 days after spray fromupper canopy of cotton plant as per standard protocol. For control of leafhopper significantly highest reduction (96.33 %) in population was recorded with flonicamid @ 100 g a.i./ha and imidacloprid @ 40 g a. i./ ha after 3, 7 and 10 days of spray. The per cent reduction of jassid was also higher in tolfenpyrad @ 125 g a.i./ha than thiomethoxam @ 25g a.i/ha after 3, 7 10 days of spray. In case of whiteflies, significantly higher reduction was recorded in pyriproxyfen @ 100 and 125 g a.i./ha (79.43 and 80.52 %) and ethion 50 EC (81.60 %) after 10 days of spray. Pyriproxyfen @ 100 and 125 g a.i./ ha (46.33 and 48.88 %) is significant safer to the natural enemy. Similarly, spiromesifen @ 144 g a.i./ha are found to be very effective against white fly nymphs population and is also safer to the natural enemies. Maximum reduction of whitefly nymphs population in the treatment of spiromesifen @144 g a.i./ha (96.26 %) followed by @120 g a.i./ha (92.67%) was observed. In case of mealy bug sulfoxaflor @ 75 g a.i./ha was found to be effective after 3 days of spray. In case of thrips significantly lower population was recorded in fipronil @ 50 g a.i./ha and 60 g a.i./ha after 3 and 7 days of spray than in imidacloprid. Among the most recent novel insecticides with selective properties, pyriproxyfen is a potent juvenile hormone analog that acts by suppressing embryogenesis, metamorphosis and inhibit adult formation of various insect pests of agriculture and public health importance (Ghanim and Ishaaya 2011**)**. The neonicotinoids used in the study has been found effective against sucking pests in the present studies and were also reported effective earlier by many workers (Mustafa 1996; Hameed et al 1997; Parsanna, 2000; Dhawan and Simwat, 2002; Vastard, 2003. The fipronil found effective against thrips in the present study was also reported effective against leafhoppers, aphids and thrips by Patil *et al (*2009).

3.33
Field evaluation of insect growth regulators, insecticides and fungicide mixture for efficacy against major cotton pests

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Since the year 2005, the transgenic cotton in Punjab has been able to suppress the bollworm complex particularly *H. armigera* successfully, which was responsible for failure of cotton during the last decade. As of now, bollworms have taken a back seat till they eventually become resistant to Cry1Ac protein produced in bt hybrids. Meanwhile, the bt cotton is facing biotic stresses mainly due to upsurge in sucking insect pests which started in 2007 with wide spread mealybug *Phenococcus solenopsis* outbreak among all bt hybrids though completely eradicated or managed later by massive campaigns undertaken by the state and central government. Thereafter, the year 2010 and 2011 witnessed heavy incidence of whitefly, jassids and thrips. Keeping in view the prevailing scenario of pest status and recurring outbreaks, the present studies were undertaken to evaluate the new molecules along with the existing ones and their mixtures against

major insect pests of cotton in 2010 and 2011. The treatments included the following: Buprofezin20%+Acephate 50%WP@ 250 + 625g a.i/ha, Buprofezin 20%@ 250 g a.i/ha, Acephate 50%WP@ 625g a.i/ha, Acephate60%WP+Kresoxim methyl 15% WG@ 750+187.5 g a.i/ha, Acephate 60%WP@ 750g a.i/ha, Kresoxim methyl 15%WG@ 187.5g a.i/ha, Acephate 75 SP @ 562.5g a.i/ha, Spinetoram 12%SC@36 and 48 g a.i./ha and Imidacloprid 200SL (Stnd Check)@ 40g a.i/ha. The study was carried out on Ganganagar Ageti (sucking pests susceptible) and included RCH 134 Bt as check against bollworms. The experiment was laid out in RBD with three replications of each treatment. The data for all the sucking pests, bollworms and predators was recorded 7 days after spray. As the jassid population was low in the year 2010, performance of the insecticides was at par and nothing could be inferred whereas in 2011, based on population reduction of jassid, Acephate and Buprofezin (alone and in mixtures) were significantly better as compared to the control. Whitefly was the lowest in the plots where Buprofezin and mixture of Acephate and Buprofezin were sprayed. In 2010, Spinetoram@48 was comparatively safer to natural enemies as results indicated their higher numbers in the plots sprayed with this molecule while in 2011, all the treatments were at par with respect to their effects on natural enemies. Thrips were managed better with the Acephate (alone and mixtures) and Spinetoram. As the level of bollworm infestation was low, per cent square and boll damage were at par in all the plots. Percent disease index (PDI) due to fungal foliar leaf spots was the lowest in the treatment receiving Kresoxim methyl in both 2010 (2.2) and 2011(4.4) followed by the mixture of the same with Acephate. Based on yield, Buprofezin and Acephate mixture gave the highest among the tested molecules in both the years of study.

3.34
Bio control agents for the management of root-knot nematode (*Meloidogyne incognita)* and root-rot fungus, *Rhizoctonia bataticola* in cotton

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Root knot nematode, *Meloidogyne incognita* (Kofoid and White), Chitwood constitute one of the important nematode pests of cotton besides other yield limiting pathogenic factors such as wilt and root rot fungus in soil. The interaction between nematode and such fungi is bound to occur due to their co habitation thus forming disease complexes in which the losses are manifold and hence their management becomes inevitable. In the present study, a complex involving *M. incognita* and root rot fungus, *Rhizoctonia bataticola* was managed successfully by using some bio-control agents applied as seed and soil treatment in 50 kg pots having root knot nematode infested and *R. bataticola* inoculated soil. The bioagents were mixed in the soil and the pots were sown with bioagents treated/untreated seeds of American cotton variety H 1098. The results indicated highest and significantly better seed cotton yield of 16.9 q/ha by soil application of *Trichoderma viride* @ 2.5 kg/ha as compared to 12.0 q/ha in untreated check resulting thereby 42.7 per cent increase in cotton yield over check. The final nematode population in soil as well in roots and root knot index was minimum and significantly lowest by the same treatment of *T. viride* @ 2.5 kg/ha which was statistically *at par* with soil application of carbofuran @ 1.0 kg a.i./ha. The per cent root rot, index was minimum (2.0) in *T. viride* compared to 14.0 in check. The incremental cost benefit ratio (ICBR) was however, highest (1:36.4) in seed treatment with *T. viride* @ 4g/kg seed as compared to 1:3.6 in carbofuran indicating thereby that soil application with *T. viride* @ 2.5 kg/ha to be the most promising bio-control agent for the management of root knot nematode and root rot fungus complex in cotton.

3.35
Isolation and characterization of diazotrophs isolated from saline and sodic irrigated soil samples

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Salinity and sodicity is one of the most important stresses that hamper agricultural productivity in nearly every part of the world. Saline soil is a non sodic soil containing sufficient soluble salt to adversely affect the growth of most crop plants with a lower limit of electrical conductivity of the saturated extract (EC_e) being 4 deciSiemens / meter (dS/m), which is equivalent to a value of 4 mmhos/cm. A sodic soil is defined as a nonsaline soil containing sufficient exchangeable sodium (Na) to adversely affect crop production and soil structure under most conditions of soil and plant type. A total of 16 soil and water samples were collected from different salt affected areas of Haryana, such as Jind, Kaithal and Karnal at a depth of 0-15cms from the rhizosphere of different crops, including cotton. These soil samples were analyzed for pH, EC, organic carbon, available P as these constituents affects plant growth. It was observed that the pH of these soil samples varied from 8.5 to 9 while EC varied from 0.2 to 1 ds/m. The pH of their respective water samples varied from 7 to 10 while EC varied from 1150 to 6200 EC X 10^6. Organic carbon of these soil samples ranged from 0.1 to 0.6% and available P ranges from 10-20kg/hac. Maximum available P was found in soil samples of Jind. Viable counts of bacteria of the above soil samples were determined on King's B, Malate, Jensen , Soil extract and on Pikovaskaya's media. Results showed that most of the isolates were gram +ve, having rod and cocci shapes, however, increase in EC results in decrease in viable counts of these bacteria.

3.36
Pre dominanance of *Rhizoctonia solani* and *Rhizoctonia bataticola* in cotton (*Gossypium* species) growing districts of Haryana

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Investigation on root rot of cotton [*Gossypium* species viz. *G. hirsutum* L., *G. arboretum* L. and *intra-hirsutum* hybrid] revealed that *Rhizoctonia solani* (Kühn.) and *Macrophomina phaseolina* (Tassi.). Goid= *Rhizoctonia bataticola* (Taub.) Butler was found dominantly in all the cotton growing regions of Haryana throughout the crop seasons during 1995 and 1996.

3.37
Impact of weather parameters on the population dynamics of Mirid bug, *Creontiades biseratense* (Distant) (Hemiptera: Miridae) in *Bt* cotton

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Cotton is one of the most important crop playing a key role in economic affairs of India. With the introduction and adoption of *Bt* cotton, the pest complex has changed considerably during the last few years. The significant relief in level of boll worms infestation by implementation of integrated pest management (IPM) followed by Bt cotton as component of IPM has led to low boll worm damage and higher yields. However these alterations along with climate changes have brought in many new biotic problems like mirid bugs (*Creontiades biseratense, Hyalopeplus lineifer* and *Campylomma livida*), mealybug (*Phenacoccus solenopsis*), bacterial blight, grey mildew, alternaria leaf spot and mosaic diseases hither to unknown or of little economic importance. Among these, the brown mirid bug *C.biseratense* has recently emerged as predominant one in *Bt* cotton in south India. In India its incidence was recorded in Karnataka (Patil *et al.,* 2006), Tamil Nadu, Andhra Pradesh and Maharashtra (Surulivelu and Dhara Jothi, 2007). Almost all the cultivated species of Bt cotton are affected by mirid bugs. The correlation between weather parameters and population has not been well documented. To study the impact of weather parameters and population of mirid bug *C.biseratense* under field conditions a study was carried out at KVK Perambalur in Tamil nadu India during 2010-11. The study indicated that the population of mirid bug was 0.10 mirids/plant during third week of September 2010 with the weather parameters of temperature (28.96°C), relative humidity (70.74 %) and rainfall (0.0 mm) which increased to 2.35 mirids/plant during the fourth week of November 2010 with the weathers parameters of temperature of (24.0°C), relative humidity (92.99 **%**) and rain fall (188.00 mm) during 95-105 days after sowing. Thereafter the population was gradually increased with the age of the crop. The population was agitated from first week December 2010 to end of January and declined gradually from February first week to and end of March 2011. From these findings, the mirid bug population showed significant negative correlation with temperature and positive correlation with relative humidity and rainfall.

POST HARVEST TECHNOLOGY
AND
SOCIO ECONOMIC DEVELOPMENT

POSTER PRESENTATION

4.1
Use of chitosan as environment friendly crease resistant finishes for cotton

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Cotton is one of the principal crops of India and plays a vital role in the country's economic growth by providing substantial employment and making significant contributions to export earnings. The cotton cultivation sector not only engages around 6 million farmers, but also involved another about 40 to 50 million people relating to cotton cultivation, cotton trade and its processing. The textile industry in India is one of the largest industries in the country. In India cotton is used extensively for apparel purpose. It is known as king of fibre. It has many qualities which make it suitable for apparel purpose such as absorbency, strength, easily spinnable, washability, and good conductor of heat. But there are certain drawbacks associated with cotton fibre or fabric such as low elasticity and low resiliency which creates wrinkles and do not recover from wrinkling readily. There is need to impart such type of finish which can solve the problem of wrinkling in cotton fibre to make it acceptable worldwide. It is found that chitosan citrate has been evaluated as non formaldehyde durable press finish to produce wrinkle resistance. Chitin is the exoskeleton of the crustaceans. Through the processing, chitin is converted into chitosan. Which have many biological properties such as biocompatible in terms of natural polymer, biodegradable, safe and non toxic. Chitosan is also utilized in medical textile because it has wound healing property. The proper utilization of these natural water resources (aquaculture) can bring the economic and academic prosperity of the nation.

4.2
Eco friendly dyeing of cotton fabric with *Pili Kaner*- A natural dye

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Cotton is a soft, fluffy staple fibre that grows in a boll, or protective capsule. Cotton has been spun, woven, and dyed since prehistoric times. Cotton can also be cultivated to have colours other than the yellowish off white typical of modern commercial cotton fibres. Naturally coloured cotton can come in red, green and several shades of brown. Cotton is natural, comfortable, versatile and fashionable. Moreover, it is an eco friendly and biodegradable fibre which is found to be very comfortable to the wearer due to its high breathability. To make it more eco friendly, it can be dyed with natural dyes rather than synthetic dyes which can be irritating to skin and harmful to environment as well. So, today in the world of growing environment consciousness among people, natural colourants have attracted the attention of everyone.

The art of dyeing with vegetable dyes has gained momentum not only from the point of view of safety of health and environment but also for their beauty, novelty and elegance. Therefore, it was felt necessary to explore natural dyes for embellishment of cotton. Various types and varieties of flowers are available everywhere in India. Some of them are seasonal and some are found throughout the year and *Pili kaner* flowers are one of them which are found every where in Haryana and available throughout the year. Commercialization of natural dyes can be done successfully by a systematic and scientific approach to extraction, purification and use of natural dyes. Optimization of extraction and dyeing conditions is a need of the hour to minimize the investment cost and overcome the variation of shade quality with the same dye. To achieve the objectives, a study was conducted to dye the cotton fabric with floral dye namely *Pili Kaner*. Different dyeing conditions like pre-mordanting with tannic acid, dye concentration (3%), dye extraction time (75 min.), dyeing time (60 min.), two mordants (Tin and Iron), mordanting method (pre-mordanting), mordant concentrations (1, 3 and 5%) were optimized on the basis of per cent dye absorption, subjective evaluation of shade produced and fastness properties. On the basis of mean scores of visual grading and fastness properties, 3 per cent mordant concentration of both the mordants shown better results as compared to 1 and 5 per cent concentration.

4.3
Cotton/polyester blend influence on parameters of weft knitted fabrics

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Cotton is the most important cash crop in India and plays a dominant role in the textile industry and thus economy of the country. In a country like India, with extremes of temperature and humidity, garments made from natural fibres in cotton or blends of manmade and natural fibres are certainly preferred to pure synthetics for reason of environment and health. The proposed study was undertaken with a view to produce cotton blended knits, which would be within the accessibility of common consumers. Six cotton varieties HS6, H1117, H1098, HHH81, HHH223 and H974 were taken for the study. After studying the fibre parameters of all the cotton varieties, the best cotton variety (H 1098) was selected for blending with other identified fibre (Polyester) by seeking the opinion of experts and consumers. Blend influence on dimensional properties of weft knitted fabrics in different ratios were studied. The P/C blended yarn in the proportions 0:100, 20:80, 40:60, 50:50, 60:40, 80:20 and 100:0 was produced by OE spinning system and blended knitted fabric was produced to study the dimensional properties. The study revealed that blending of cotton with polyester in different ratios was found to improve certain properties of cotton as well as polyester yarn. The dimensional properties loop length, bulk and area shrinkage decreased significantly where as stitch density and tightness factor increased significantly with the increased proportion of polyester in the blend. Moreover, as there is a dire need of meeting the raw material crisis of natural fibres, it was intended that there should be some low priced substitute. Being the producer of cotton, the rural masses can take up knitting as a income generating source, to set up a small scale enterprise.

4.4
Cotton *durries* – Rural homes to designer homes

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Durrie is a smooth, hard, flat woven, pile less cotton fabric, usually in simple stripes in different colours. It is generally used as bed spread and are woven all over the country in infinite varieties. In Haryana, majority of the respondents always used hand spun cotton yarn (4 and 6ply) for warp and (6 and 8ply) for weft in the northern region. Whereas in the southern region all weavers always used machine spun cotton yarn ($4/6_S$ and $5/10_S$) for warp, and hand spun ply yarn made from used cotton (*loggar)* was sometimes used by few respondents. The concept of a *durrie* has changed over the years as *durries* have gone up with fancy colours, designs and the fairly down-to-earth floor wear has suddenly turned designer and outlets in big cities are as *durrie* boutique. Ten preferred designs using four preferred designing techniques were used and forty d*urrie* samples were got prepared for market acceptability. New techniques in pre- weaving, weaving and post- weaving processes were found helpful for making better products at lower prices and in new ranges. As the hand made designer durries have come in to textile scène like a breath of fresh air. Being cheaper than carpet, lighter, easy to maintain, reversible in use and wide range of colours has made it possible for even young, budget conscious home makers to mix and match and redecorate. Being a relatively small investment one can dispose it of and select the product that suit the changing seasons, mood of time, suitability and has multipurpose use as floor covering, *diwan* cover, wall piece, car cushion, *aasan*, table cover etc. A few options of multipurpose use were offered for consumers' opinion in the present studies. The list could be longer based on individuals, thoughts, tastes, visualization and creativity of mind.

4.5
Factors affecting technological information source utilization pattern for cereal and cotton crops

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The present study was designed with a specific objective to identify factors affecting technological information source utilization pattern regarding different cereals and oil crops . The present study was conducted in six district of Haryana and one block from each district and two villages from each block were selected for the present study. Thus, twelve villages from six districts were selected on the basis of crops grown in area. So proportionate random sample were drawn from each villages which is comprising of 485 rural women who were selected purposively as the main crop grown in the district . It is therefore concluded that correlation coefficient of use of communication source with independent variables found that occupation with localite source and age with mass media source of information was found to be negatively correlated

whereas other variable could not exert their influence on independent variable regarding wheat cultivation. Correlation coefficient of use of information sources with independent variables regarding rice cultivation revealed that education and land holding were negatively and family size was positively correlated with localite source as well as in pooled sample. No other variable could exert their influence on frequency of use of information sources. Whereas correlation coefficient of use of information source with independent variable regarding cotton cultivation were found that land holding positively and significantly associated with frequency of use of cosmopolite source as well as in pooled sample, whereas education was found positively and significantly associated with frequency of use of mass media source.

4.6
Eco friendly antimicrobial finish for cotton fabric

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In the present scenario of environmental consciousness, the new quality requirements not only emphasize on the intrinsic functionality and long service of the product but also a production process that is environment friendly. In the current study an attempt has been made to develop the eco-friendly antimicrobial finish for 100 per cent cotton fabric from *neem* (*Azadirachta indica*). Antimicrobial finish has become more important for the cotton textile materials especially used in sportswear and casual wear because they can easily be contaminated by perspiration leading to bacterial growth and body odour. The enzymatic treatment was given to remove impurities from the grey cotton fabric and to increase the absorbency of antimicrobial agent. Methanol was used as a solvent for *neem* extraction from *neem* leaves. *Neem* extract at two concentrations *i.e.* 3 and 5 gpl was applied to the enzymatic scoured and controlled samples by exhaustion and pad dry cure method on cotton fabric. Citric acid (8% owf) was used as across linking agent. The total weight add on per cent of the *neem* treated cotton fabric was also calculated to estimate the actual amount of extract absorbed by the fabric. The finished fabric samples have been tested for antimicrobial activity as per serial dilution method**.** The antimicrobial activity of enzymatically scoured and controlled cotton samples have been compared and found that pre treatment with enzymes were quite important for absorption and diffusion of *neem* on cotton fabrics. The treated cotton fabrics have shown excellent antimicrobial activity at 5 gpl concentration. The wash durability of the treated sample was tested by using standard ISO: 6330-1984E and found good even after 15 washing cycles. Application of extract by exhaust method has shown better results than pad dry cure method.

4.7
COT BAG: Drudgery reduction device for farm women

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Women are engaged in various agricultural operations like transplanting, weeding, harvesting, picking and post harvesting. Despite significant contribution of women in these activities, those engaged in the formulations of policies have often tended to neglect the productive role of women. All these tasks are time consuming and full of drudgery over the years though there is a paradigm shift towards women empowerment that is not enough. Access to affordable technology reduces drudgery, save time and increases work efficiency of women. Adoption of such technologies radically changes their life. Cotton picking is laborious nature of work where swift hands of women folk are appreciated as compared to men. Despite the technological advancement and farm mechanization jobs attended by women in agriculture remained more or less same. Efforts have been made to develop women friendly cot bag, which would reduce the drudgery and increase their efficiency. Cotton picking bag has been designed by department of textile and apparel designing. The present study was carried out in pre-dominantly cotton growing area namely Sirsa and Fatehabad district of Haryana. Four villages namely Nezadela and Bajeka from Sirsa and Bighar and Badopal from Fatehabad districts were randomly selected for the purpose. 20 farm women from each village, totaling 80 respondents were selected for intervention programme. Gain in knowledge, skill acquisition and perceived feasibility of cot bag was carried out after completion of intervention programme. Perceived feasibility on five attributes was found 82.61 per cent. Physical and cultural compatibility attribute was ranked highest with AFI 92.66 percent. It was followed by relative advantage (89.58%), triability 88.91 per cent. However, simplicity-complexity was found 61.80 percent comparatively low index because of cognitive complexity. Grey cotton fabric of 60" width was perceived most appropriate for stitching, because of low wastage and ease in measurements. Respondents got medium extent of skill acquisition regarding stitching of cot bag.

4.8
Physiological and biomechanical stress analysis of women engaged in cotton picking - a Haryana study

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India is a major cotton producing country and occupies about 23 per cent area under it. Haryana state has a significant contribution to nation's production. Cotton picking is more or less a farmwomen's responsibility in most part of India especially in Haryana. Farm woman has a major role in cotton cultivation. Present study was undertaken to determine the physiological and biomechanical stress of women involved in cotton picking. Field experiment was carried out for one hr on 60 farm women of Haryana belonging to two age groups *i.e.* 25-35 and 35-45 yrs. Farm women collected 4.9 kg of cotton and traveled a distance of 2.72 km during one hour of cotton picking activity. Average working heart rate of woman increased up to 102b/min

during the activity over the resting HR (78b/min). Energy expenditure was more in older age group (7.7 kj.min^{-1}) than younger group (7.0 kj.min^{-1}). Women perceived heavy to moderately heavy exertion after the activity. Grip strength increased up to 9.6 per cent during the activity whereas it decreased by 14.3 per cent at the end of the activity. During the activity, women usually adopted unnatural body postures leading to drudgery in the form of various kinds of musculoskeletal discomfort especially in wrists, lower back, upper back etc. Severe discomfort was reported in fingers (m.s.= 4.8) as they get abrasions while plucking cotton pods followed by mid back (m.s.= 4.4) and wrists (m.s.= 4.1) and shoulder (m.s.=3.8). Hence, there is a need to develop appropriate technology that would reduce drudgery of women in the form of ready to wear cotton-picking bag and finger guards to protect them from injury from pod shells during cotton picking. Adequate rest pauses coupled with training on use of proper body postures need to be given during the work to delay the onset of fatigue and its recuperation.

4.9
Evaluation of front line demonstrations in *Bt* cotton

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Kaithal has been a traditional rice-wheat belt where rice occupies about 99% of the cultivated area during *kharif* season. Due to continuous cultivation of a few predominant varieties, the problem of water and nutrient depletion, minor insect pest acquiring major status, continuous build up of insect-pest and disease inoculum year after year led to static production. Further, the popularization of high yielding varieties, excessive use of fertilizers particularly nitrogenous ones coupled with marginal benefits to the growers aggravated the situation. At this critical juncture, Krishi Vigyan Kendra, Kaithal introduced cotton in the district where irrigation facilities are scarce. Cotton crop picked up gradually in the areas of Kalayat, Rajond and parts of Kaithal block. Front line demonstrations were conducted in Kaithal district to exhibit the improved production and protection technology to the cotton growers in order to popularize the crop and to bring about diversity the present cropping system. Field data were collected from demonstration as well as non demonstration fields to know the yield gap and extent of technology adoption so as to make demonstrations more effective and meaningful. Soils of the area are clay loam to loam with pH ranging from 7.6 to 8.4. The field selected were under irrigated farming situation. Recommended package of practices were followed by the farmers for cultivation of *Bt* cotton. To assess the technology and its adoption, technology gap, extension gap, technology and adoption index were calculated. Cost of cultivation and monetary returns were also estimated to find out the incremental cost benefit ratio. The results of front line demonstrations (FLD) conducted at farmers field revealed that the yield of demonstration plots varied from 2830 kg/ha. to 3320 kg/ha with an average of 3050 kg/ha. However, the realized yield was lower than the potential yield (3500 kg/ha) despite the demonstrations were conducted under guidance of extension scientists. The differences might be due to variation in soil health conditions, suitability of varieties to particular geo agro climatic conditions and location specific management. Further, the influence of abiotic factors affecting the critical growth stages of crop can not be underemphasized. A technological gap of 450 kg/ha with technology index 13.8 indicate fairly good provision of improvement for attaining the potential yield. An increase of 9.1 per cent in yield of demonstration yields was observed over farmers practice. This indicated an extension gap of 280 kg/ha for which there appears a need for training and education of farmers for adoption of scientific crop production technology. An adoption index of 62 clearly shows that

farmers have responded to the technical knowhow. Extension programmes based on latest scientific recommendations with emphasis on critical management practices need to be organized. The perusal of data revals that the recommended practices in FLD has increased the yield by 9.1 per cent over farmers practice. The incurring of Rs. 2500/ha in FLD's has resulted in Rs. 7000/ additional returns. The profitability has been studied by estimating the incremental cost benefit ratio (ICBR) and an ICBR of 2.8:1 indicate that a small increase in investment on improved practices result in substantial gain thereby increasing the benefits to the grower.

4.10
Evaluation of *Bt* cotton hybrids through front line demonstration at farmer's field in Sirsa district of Haryana

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Cotton is the most important fibre crop of India and plays an important role in agrarian and industrial economy. Area under *Bt* cotton is increasing tremendously and at present about 85-90 per cent of cotton cultivated area is under *Bt* cotton hybrids. The full yield potential of *Bt* cotton hybrids can be exploited under favourable environment *viz.*, fertile soil, irrigation weed management and fertilizer application. Crop management play a important role for realizing higher productivity of improved crop variety. The frontline demonstrations were conducted at farmer's field during 2005-2006 and 2006-2007 in Sirsa district of Haryana for assessing the yield potential of *Bt* cotton hybrids over the existing cotton cultivars. The study was conducted on different *Bt* cotton hybrids *i.e.* MRC 6301, MRC 6304 and Rasi 134. The *Bt* cotton hybrids cultivation in demonstration plots increased yield over traditional farmers cultivars to extent of 53.95 per cent. The extension gap ranged form 8.33 to 10.16 q/ha. The extension gap of the yield was 8.87 q/ha. The results indicate sizeable loss of productivity at farmer's field due to adoption of old technology i.e. non *Bt* cotton cultivars. This necessities refinement of existing technology in consonance with local resource conditions, along with innovative extension strategies to bridge the technological and extension gap.

4.11
Productivity and economics of *Bt* cotton as influenced by plant geometry and nitrogen levels under irrigated and rainfed conditions

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A field experiment was conducted at Agronomy Farm, Marathwada Krishi Vidyapeeth, Parbhani during *kharif* 2009-2010 and 2010-2011 in split plot design which replicated thrice. The soil was medium deep black with low available nitrogen, medium in available phosphorous and high in available potassium. There were eighteen treatment combinations comprising two irrigation treatments *viz.*, irrigation (at critical growth stages) and rainfed in main plot, three crop geometries *viz.*, 90 x 60 cm, 120 x 45 cm and 180 x 30 cm in sub

plot and three nitrogen levels *viz.*, 100 kg N/ha, 125 kg N/ha and 150 kg N/ha in sub-sub plot. Application of three irrigations at critical growth stages of cotton recorded significantly higher growth and yield contributing characters, seed cotton yield, net returns and B:C ratio as compared to rainfed cotton during both the seasons and in pooled data. The plant geometry 120 x 45 cm recorded highest seed cotton yield, net returns and B:C ratio and stood significantly superior over 90 x 60 cm and 180 x 30 cm plant geometries. Application of higher dose of nitrogen 150 kg N/ha significantly improved the seed cotton yield, net returns and B:C ratio over lower levels of nitrogen. Seed cotton yield was increased linearly with increasing levels of nitrogen from 100 to 150 kg/ha. Therefore it is concluded rat irrigated *Bt* cotton is rows at 120 x 45 cm plant geometry with application of 50 per cent extra nitrogenous fertilizer to achieve maximum profit during *kharif* season.

4.12
Biological softening of cotton plant stalk for preparation of binderless boards and paper

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In India cotton plant stalk is treated as waste though a part of it is used as fuel by rural masses. Cotton plant stalk is rich in cellulose. An attempt has been made to prepare binderless boards and pulp from cotton plant stalks by resorting to a new biological process. The biological pretreatment aimed at in the present investigation completely replaces the conventional thermo mechanical pulping process. The cocktail of enzymes in the active system elaborated mostly by anaerobic microorganisms assisted by the presence of aerobic flora are responsible for softening the lingo cellulose complex. The effect of anaerobic process on various properties binderless board as well as on paper was evaluated. In case of binderless boards the results indicated that there was not much change in the chemical composition after one day of anaerobic treatment. As the number of days of anaerobic treatment increases reduction in the percentage of pulp yield was observed. The properties of the board obtained by this process satisfy the BIS specification excepting the water absorption. Additional advantage of this new process indicates that there is about 40 per cent saving in energy as compared to thermo mechanical pulping method. In case of pulp and paper preparation the chemical and energy requirement for production of pulp by this process is very low as compared to the conventional chemical process. This makes the process eco-friendly and economical. The use of cotton plant stalk for the production of pulp and paper will not only solve the disposal problem of this agro waste but also help to meet the scarcity of raw materials for paper manufacture.

4.13
Impact of anaerobic treatment on the chemical composition of cotton plant stalk

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Cotton plant stalk is a residual material generated by cotton cultivation. In contrast to other agricultural crop residues, cotton stalk is comparable to the most common species of hardwood in respect of fibrous structure and hence it can be used for the preparation of various value added products, one of them is pulp and paper. Standard conventional chemical processing of pulping involves cooking of cotton plant stalks in a digester under high temperature and pressure in the presence of chemicals. The effluents generated during this process causes environmental pollution. Biological processes offer an ideal and appropriate solution in this context. A large number of fungi and bacterial are found in nature, which can degrade lignin as well as other components of plant under aerobic as well as anaerobic conditions. Employing these microorganisms for softening of cotton plant stalks prior to chemical pulping can result in saving energy and chemicals.

4.14
An economic analysis of *Bt* cotton in Haryana

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Cotton is a crop of tropical region and its cultivation is concentrated mainly in Asia. India cultivates around 12 million ha, the largest in the world acreage (about 34%) and second largest producer only next to China (about 22%) . The area under cotton crop was 56 lakh ha in 1950-51 has shown consistent increase till the early eighties. The serious insect-pest problem on cotton in Ninties causing fast decrease in average yield at Compound Growth Rate (CGR) of (-0.41%). In 2002 introduction of *Bt* strain has given a revival to cotton crop and indicated a highest annual CGR i.e. (11.2%) yield during the past one decade. In India share of Haryana in area and production of cotton in India was 4.92 and 7.15 per cent, respectively during the year 2011 (CAB). The area and production increased from 1.83 lakh ha and 3.06 lakh bales in 1966-1967 to 6 lakh ha and 25.4 lakh bales respectively in 2011. In Haryana state, three districts *viz.,* Sirsa, Hisar and Fatehabad account for about 76 per cent of the total area under cotton. The present study was conducted in these three districts of Haryana during the year 2011. A sample of four villages from each district was selected randomly with a sample of about 120 farmers consisting of 10 farmers from each village. The study revealed that total cost of cultivation of *Bt* cotton was ₹ 25945, 24965, and ₹ 24801/ac in Sirsa, Hisar and Fatehabad district, respectively. Among operational cost, picking charges were at the highest being ₹ 5182.7/ac which accounted 20.53 per cent of the total cost of cultivation on an average in these districts. Similarily, the material cost was observed as ₹ 6070 which accounted for 24.05 per cent on an average. *Bt* cotton seed being very expensive it was the major item in material cost which accounted for

₹ 1776 and 7.04% of the total cost. Among fixed cost items rental value of land had the major component of ₹ 6465/ac and accounted 25.62 per cent on an average and it was highest in Hisar district. On an average risk factor and management charges were found 6.12 per cent each of total cost. On an average with the production of *Bt* cotton 9.5q/ac fetched gross return of ₹ 40791/ac including the value of by product on an average. The net return for *Bt* cotton in Sirsa, Hisar and Fatehabad districts were ₹ 14096, ₹ 16575, and ₹ 15991 while cost of production/q, was observed to be ₹ 2851, ₹ 2574, ₹ 2557, respectively in these district. Thus it could be safely concluded that *Bt* cotton is profitable crop and it has given impetus to the cotton production in the state again which suffered a set back in the ninties.

4.15
Indebtedness issues of cotton farmers in distressed and non distressed districts in Andhra Pradesh: A comparative study

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As per the report (2006-2007) prepared by the Ministry of Agriculture and Co-operation, Govt. of India, 11782 farmers have committed suicides in the country during last five years. Most of these suicides have been reported from cotton growing areas of Maharasthra, Andhra Pradesh, Karnataka and Punjab and other states. The report further states that cotton growers are not able to get the remunerative prices to their produce. An attempt has been made in this study to look at the indebtedness issues of cotton growers. The study was conducted in Karimanagar (distressed district) and Khammam (non-distressed district) districts, where in large area under cotton and considerable suicides happened in one and not in another district. From the selected districts, four mandals having larger area under cotton cultivation were selected purposively. Thus eight mandals were selected for the study. Based on comparatively larger area under cotton cultivation, 20 villages from each district, comprising four villages from each mandal were selected. Thus present study was confined to 40 villages. From among the selected villages, a comprehensive list of cotton growers was obtained and 100 farmers from each district were selected. It could be observed from the findings that about 40 per cent of the loans are taken from formal sources while the rest 60 per cent from informal sources by the respondents of distressed districts. In contrast, the respondents from non distressed districts sourced major source of loan (55 %) from formal sources followed by informal sources (45%). Among the informal sources money lender source contributes more than 80 per cent in both the categories. Among formal sources cooperative societies contributes 32.84 per cent followed by rural banks (26.5%), urban banks (20.84%), commercial bank (12.35) and cooperative bank (7.13). the results observed that the benefit cost ratio in the non-distressed district is -0.16 which is highly discouraging. With regard to share of different costs, labour costs contributing about 30 per cent of the total cost of cultivation. Material cost contributes about 27 per cent and remaining 43 per cent towards fixed costs. It indicated that fixed cost share is much higher than normal. While the benefit cost ratio in the distressed district is 0.127 is encouraging. With regard to share of different costs, labour costs contributing about 44 per cent of the total cost of cultivation. Material cost contributes about 36 per cent and remaining 20 per cent towards fixed costs. It indicates that labour cost share is increasing with increasing labour wages and corresponding share in material is decreasing because of less plant protection costs.

4.16
Reasons for discontinuation of *Bt* production technologies by the *Bt* cotton growers and non *Bt* cotton growers in Tamil Nadu

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The study was conducted at Kovilpatti block of Tuticorin district of Tamil Nadu with the specific objective of studying reasons for discontinuation of the *Bt* production technologies among *Bt* cotton growers and non *Bt* cotton growers. The area was selected based on the major area under *Bt* cultivation and production of *Bt* cotton under irrigated condition. The selected respondents for this study were 90 numbers, who have adopted *Bt* cotton and non *Bt* cotton *i.e* 45 growers in each category by using simple random sampling method. The collected data were analyzed using percentage analysis. The study revealed that 71.11 per cent of the *Bt* cotton growers were expressed high labour cost and non availability of labour during peak periods of crop growth. And *Bt* cotton is non-viable especially for small farmers due to susceptibility to pink boll worm attack and as well as *Bt* varieties developed were themselves moderate to poor yields. Also, 64.44 and 62.44 per cent of the *Bt* cotton growers reported that uneven seasonal rains and heavy incidence of pest and diseases which occurs during flower formation to boll setting stages of crops results in continuous presence of water stagnation in the cotton field makes it easy for pest bollworm infestation which comes back more aggressively after 90 days.Further, diseases and other biotic stress agents also multiply and cause frequent epidemics. Whereas 91.11 per cent of the non *Bt* cotton growers expressed non availability of labour in time which was reported as major reason for discontinuation of *Bt* cotton followed by high cost of seed (88.88%), high risk managements (84.44%),lack of technical knowledge and skill (82.22%). The non *Bt* cotton growers were not ready to take risk and also not interested for adoption of *Bt* cotton. They preferred to go for low risk management crops *viz.*, maize/sunflower/pure cropping of black gram which are the choice to adopt by the non *Bt* cotton growers. The study also revealed that after *Bt* cotton was harvested, the soil conditions deteriorate to the extent that a crop like turmeric cannot be grown as succeeding crop. Farmers have begun noticing that, after 3-4 successive years of *Bt* cotton, the incidence of bollworm as well as the need to spray pesticides were increased. Farmers used non *Bt* seed for gap filling, fewer and fewer farmers are taking care of refuge criteria. And other problems like wilt, drying up of *Bt* cotton plants, flowers and bolls etc., were also occurred in critical growth stage of boll formation which resulted due to uneven rains prevailed. Moreover proper monitoring by company representatives or government officials was absent during adverse effects which occurred in cotton fields most cases.

4.17
Scenario of cotton area, production and productivity in North zone

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Cotton (*Gossypium* spp.) is one of the most important commercial crop playing a key role in economical, political and social status of the world. Popularly known as 'White Gold' is a premier cash crop of the most SAARC countries with an enormous potential of sustainable employment generation both in rural and urban sector. Cotton is an important fibre crop and known as "King of Fiber Crops" of India and contributes too much for the national exchange. Cotton enjoys a pre eminent status among all cash crops in India by providing principal raw material for textile industry providing 27 million bales of lint to the industry. In Haryana, cost of production is very high due to indiscriminate use of chemical fertilizers and pesticides. Lack of post harvest management practices, damage during transport, market yard, ginneries and fraudulent mixing of varieties are some of the important issues for high variability of fibre parameters in Indian cotton. The present study examined the trend in area, production and productivity of cotton in northern states. The area under cotton was 13.22 lakh ha during 2003-2004 in northern zone and reached to 20.45 lakh ha during 1996-1997 which few fluctuations, declined afterwords and reached 16.95 lakh ha during 2011-2012. The area under Haryana was 5.26 lakh ha during 2003-2004 and reached to 6.05 lakh ha during 2011-2012. Similarly in Punjab it was 4.52 and 5.60 while it was 3.44 and 5.30 lakh ha during the same period. The area was highest in Haryana of north zone as compared to Punjab and Rajasthan. The production of cotton was highest during 1991-1992 at 48 lakh bales and remained 56 lakh bales during 2011-2012. No doubt that significant enhancement of area under cotton this year, but the productivity hovering around 500 kg/ha for the past 6-7 years which is need to be enhanced with perspective plan like discontinuation of cotton cultivation wherein the productivity is very low and identification of newer or non traditional area which can boost the productivity level in the country. The productivity of cotton varied believe in 398.64 kg/ha to 567.67 kg/ha during this period. In Haryana state area under cotton increased significantly but overall the growth rate of area was positive and significant. Overall the production of cotton in Haryana increased at the rate of 2.59 per cent per annum. The production in Haryana was 11.50 lakh bales during 2003-2004 and touched to 20.00 lakh bales during 2011-2012. Similarly, in Punjab it was 10.35 and 19.50 lakh bales and it was 9.15 and 17.10 in Rajasthan during the same period. Overall the area, production and productivity of cotton did not follow a consistent pattern, wide fluctuation were observed in all the states of north India. The productivity during the same period in Haryana was 371.67 and 561.98; In Punjab it was 389.27 and 591.96 while it was 452.18 and 548.49 in Rajasthan. The productivity was 398.64 and 567.67 during the same period in north zone. The coefficient of variation (cv) in Punjab varied between 10.88 to 13.24 per cent, Haryana between 9.46 to 22.46 per cent and Rajasthan between 10.70 to 14.57 per cent for the period under study. The CV for productivity ranged between 23.28 to 31.08 per cent for Punjab 15.80 to 28.36 per cent for Haryana and 16.25 to 42.05 per cent for Rajasthan. No systematic trend was observed. The changes in cost and returns in cotton during pre and post-Bt period was also examined in Haryana. The cost of cultivation data was obtained and costs and prices was analysed using simple tabular analysis. The analysis revealed that cost of cultivation increased during post Bt period as compared to pre *Bt* period. The seed cotton yield/ha showed increasing trend making cotton cultivation more profitable during post *Bt* period.

4.18
Role of *Bt* Cotton planter in enhancing the productivity in the scenario of climate change

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Many factors are responsible for lower productivity but some of the major reasons are timeliness of sowing, depth of sowing and sowing at optimum moisture content. These constraints are being tackled by the introduction of *Bt* cotton planter which has the inclined cell type metering mechanism for maintaining very low seed rate at proper depth. The farmers of the Haryana state have adopted this machine in a very big way. The cumulative population of *Bt* cotton planter has reached 9580 in the year 2011-2012 from the modest cumulative population of 50 in the year 2004-2005. The exponential growth is due to the fact that it has benefit cost ratio of 1.47 and the average area covered by one entrepreneur is 50 ha/year. The importance of this machine has increased manifold, as with this machine, timely sowing of the crop at optimum moisture content can be achieved resulting in better germination. Prior to the introduction of this machine, farmers used to sow their crop manually by applying more water in pre-sowing irrigation for maintaining proper moisture content due to prolonged process of manual sowing, thereby resulting in depletion of water resources and consumption of more energy in the crop production. Thus, the lifting of more water and usage of more energy has detrimental effects on the environment and ultimately resulting in global climate change.

4.19
Effect of washing on the fenvalerate contaminated fabric

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Pesticide may pose direct risk to applicator and indirect risk to applicators' family. Fenvalerate which is a synthetic pyrethroid has wide acceptance in agricultural usage due to its high insecticidal activity against a number of insects, pests, moderate mammalian toxicity and adequate stability in the field. Ordinary laundry does not remove the pesticide from clothes. Here an effort has been made to study the effect of washing on fenvalerate contaminated clothes. The study was conducted in five villages for analyzing washing practices of 50 rural women. Based on the prevalent practices of sprayers, one simple detergent and one enzyme containing detergent were procured from Hisar city with pH 10.15. Steeping time of 30 min. prior to actual washing was taken for the experiment. The selected samples were sprayed with two doses of fenvalerate and washed after 24 hr. Their residual levels were checked and compared with the control sample. The residual levels were higher in samples washed with simple detergent and samples having single rinsing as compared to samples washed with enzyme containing detergent samples having triple rinsing. It showed that there was a significant difference in the amount of residual in all treatments. For both of the sprayed samples the residue levels were highest in control samples. The reduction in residue levels were highest

in samples washed with enzyme containing detergent given three rinsing. The findings of the study highlighted that clothes of terrycot fabric should be used during spray and enzyme containing detergent should be used for washing contaminated clothes. These should be steeped atleast for 30 min before washing required to rinse at least three times with plain water.

4.20
Impact of growing of cotton crop with drip irrigation on socio economic status of the farmers

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Cotton is the most important commercial crop of India contributes to around 60 per cent of the raw material to the textile industry and provides employment to nearly 60 million people with productivity of 494 kg/ha. It is predominantly cultivated as a rainfed crop, because of inherent problems associated with the surface irrigation and increased water scarcity, farmers are not able to supply water at the required time interval for cotton. As a result, farmers are not able to increase the productivity of the crop despite using required yield increasing inputs. The productivity of cotton crop is one of the lowest in the world. Realizing the importance water, drip irrigation system (DIM) for saving the water and to increase the productivity seems to be the best alternate in the present system. Therefore, attempt has been made to study the impact of growing of cotton crop with drip irrigation on socio ecomic status of the farmers along with constraints involved in it. Study was conducted in 4 blocks of Bhiwani district of Haryana State. Out of these, 85 farmers from 18 villages were surveyed who were growing cotton with drip irrigation. Analysis revealed that all farmers who adopted drip irrigation on cotton crop had favorable attitude towards it. Majority of farmers had high (64-70%) level of knowledge and high level of adoption of drip irrigation (58.82%). Large majority of sampled farmers were found growing cotton with drip irrigation (72.44%). Rest were growing horticultural crops. Level of adoption of drip irrigation on cotton crop was found significantly associated with educational level of farmers, size of landholdings, level of extension contacts, level of mass media exposure and socio-economic status. Regarding the economic impact of cultivation of cotton crop with drip irrigation, all farmers reported increase in water saving, decrease in labour cost and increase in cultivated area. Likewise 93.82 per cent each reported increase in yield and decrease in crop loss due to water shortage, reduction in cost of cultivation and increase in profit. Similarly benefits like increase in income, saving of time, etc. were also reported by more than 80 per cent of the farmers. Due to multiple economic benefits, overwhelming majority of farmers reported many social effects like improvement in socio economic status (94.12%), increase in social recognition and increase in extension contacts (91.76%), increase in mass media exposure (89.41%), increase in urban contacts (87.06%). Similarly, farmers also reported improvement in dress pattern and educational level (68.24%) and improvement in quality of health services availed (67.06%) and change in attitude towards social issues. etc. Regarding constraints, most of cotton grower farmers reported irregular power supply (100%), not getting actual price (72%) and loss of crop due to attack of *ukhera* disease (15%) and get adulterated seeds (5%).

4.21
Cotton production and consumption in Bangladesh

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Bangladesh produces some cotton though it can not be termed as cotton-producing country. The textile sector has emerged as a dominant player in the economic development of Bangladesh. The emergence and meteoric growth of the highly labour intensive ready-made garments (RMG) sector in the last three decades significantly encouraged the development of the capital intensive primary textile sector (PTS) in this country. Assuming normal monsoon conditions, MY 2012-2013 domestic cotton production is forecast at 1,20,000 Bangladeshi bales from 40,000 ha. MY 2011-2012 cotton production is estimated at 95,000 Bangladeshi bales, harvested from 36,000 ha. Of this amount 87,000 bales were medium staple American variety and 8,000 bales of short staple upland. Bangladesh has a Cotton Development Board (CDS) and all activities of cotton production are being conducted by it. The CDB strategy includes an expansion of the use of new high yielding varieties, the introduction of summer cotton and gradually converting 20,000 ha from tobacco to cotton cultivation. Despite this increase, under normal conditions, domestic production is unlikely to exceed 3 per cent domestic raw cotton demand cause the trade situation is expected to improve and also a new mill spring into operation almost every month. Raw cotton consumption in MY 2011-2012 is estimated at 3.5 million bales down by about 5.5 per cent from MY 2010-2011 due to a sharp decline in imports as well as weaker demand from spinning sub-sector. Maximum portion of raw cotton requirement are met from the imported cotton. Local production can meet only 3 per cent of the requirement. Remaining 97 per cent are imported from different countries including Uzbekistan, India, USA, Australia, Pakistan, Sudan, Uganda, Turkmenistan, Kazakhstan, Egypt, Zimbabwe, Nigeria, South Africa, Cameroon etc. Uzbekistan and India are the major suppliers of raw cotton to Bangladesh due to competitive prices and short delivery periods. Raw cotton imports in MY 2011-2012 are estimated at 3.25 million bales a 12 per cent decrease from the previous year. Many Bangladeshi buyers are currently facing contract payment problems. The Indian ban on cotton exports has also had a detrimental impact on supply. As market conditions stabilize, industry observers expect that trading volumes will resume. In MY 2012-2013, raw cotton imports are forecast to reach 3.6 million bales. The procedure for importing cotton into Bangladesh is fairly simple. Only US cotton needs to go through a fumigation process. Bangladesh importers follow ICA rules and contracts with two exceptions for Egypt and Government companies in India. Payment is done through letter of credit. Contract parameters mainly cover staple length, micronaire range and strength of the cotton. Spinners receive advance fiber information measured using the HVI and it is generally recommended in lieu of individual testing instruments. Buyers in Bangladesh prefer to establish long term relationships with a few agents who represents reputable trading companies in various cotton exporting countries.

4.22
Classification of cotton plants using decision tree

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Cotton is an important commercial crop in the world. In India it is mainly grown in the north western part, particularly in the states of Punjab, Haryana and Rajasthan. Cotton provides fibre, feed, fuel and vegetable oil. Cotton yield can be improved by improving plants/unit land, balls/plant, and seed/boll or fibre/seed weight by improving of one or many components. Keeping in view, the classification technique of the data mining can be used for analyzing the various varieties of the cotton to find the best varieties in various regions. Data mining is the extraction of hidden predictive information from large database; it is a powerful new technology with great potential to analyze important information in the data warehouse. Classification is one of the techniques of the data mining which classify the given data based on many attribute given in the database. It is also known as supervised classification. This approach normally uses a training set

where all objects are already associated with the known class labels. The classification algorithm learns from the training set and builds a model. The model is used to classify new objects. It is an attempt to apply classification techniques of data mining on the cotton database and to find out some hidden knowledge which can further use to improve the yield. For this cotton database of Hisar region is extracted from the Department of Cotton, CCS HAU Hisar. A popular Data Mining software *i.e.* WEKA (Waikato Environment for Knowledge Analysis) is used for this purpose. It provides a GUI interface for applying data mining techniques on large datasets. Classification techniques (Decision Tree) of data mining have been applied on cotton database of Hisar region using WEKA tool and observed that the productivity of cotton varieties like CSH 2838, CA 105, LH 2256, CSH 3088 is high; so farmers choose these varieties for cultivation whereas GJHV 398, TCH 1740, CNH 50, RAH 1003 have low productivity so they are not being chosen for cultivation. Data available for this is very small, this method can be applied on huge data which have large number of attributes and can find out the productivity of various breeds based on various attributes like weather conditions, availability of water, soil types in future which helps farmers to choose better variety for cultivation. So that maximum productivity can be achieved.

4.23
Performance of white leghorn layers under feeding of *Bt* and non *Bt* cotton seed

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An experiment was conducted at Nagpur [21 ^{0} N 09' 0" N and 79 ^{0} 09' 0" E] to study the effect of feeding seed of *Bt* cotton and non *Bt* cotton on the growth, productive performance, health status and survivability of White leghorn pullets (layers) and to assess the wholesomeness of *Bt* cotton seed for feeding to them. No significant difference (P > 0.05) was found in the average live body weight of layers fed with concentrate comprising *Bt* cotton seed cake (T_1), group of layers fed with concentrate comprising non *Bt* cotton seed cake (T_2) and group of layers fed with concentrate comprising no cotton seed cake (T_3) during the experimental period. The layers in T_2 produced highest number of eggs (449) followed by layers in treatment T_1 (365) and the least by the layers in treatment T_3 (308) and statistically the same was found to be significant (P < 0.05). Apparently the average egg weight was highest in treatment T_3 (55.91 g) followed by treatment T_1 (49.84 g) and the least in treatment T_2 (48.98 g) but, statistically the same was found to be non-significant (P > 0.05). Apparently the average egg length was highest in treatment T_1 (52.3 mm) followed by the layers in the group of layers in treatment T_2 (52.1 mm) and the least in treatment T_3 (51.5 mm) but statistically the same was found to be non significant (P>0.05).Apparently the average egg width was maximum in treatment T_1 (40.1 mm) followed by treatment T_2 (39.8 mm) and the least in treatment T_3 (39.8 mm) but statistically the same was found to be non significant (P > 0.05).The average shell weight was maximum in treatment T_2 (3.79 g) followed by treatment T_1 (3.51 g) and the least in treatment T_3 (3.34 g) and statistically the same was found to be significant (P < 0.05).The average shell thickness was maximum in treatment T_2 (0.30 mm) followed by treatment T_1 (0.28 mm) and the least in T_3 (0.23 mm) and statistically the same was found to be significant (P < 0.05).The crude protein (CP) percentage of seed of *Bt* cotton was observed to be more by 5.88 per cent than CP percentage of non *Bt* cotton seed. The CP percentage of cotton seed cake (CSC) obtained from seed *Bt* cotton was observed to be more by 3.5 percent than CSC obtained from non *Bt* cotton seed. During the experimental period, the average feed consumption of layers was observed to be similar (120 g/head/day) in all the three experimental groups. No gastrointestinal problems and or any other diseases were observed in case of any of the layers. No adverse/ deleterious effect of feeding cotton seed cake obtained from seed *Bt* cotton was observed on the health of layers. During the experimental period, there was maximum mortality in treatment T_3 *i.e.* control (26.7 %) followed by treatment T_2 (20 %) and the least (13.3 %) mortality in treatment T_1.Hence during the entire length of experimentation, the survivability of experimental layers was found to be maximum in treatment T_1 (86.7 %) followed by treatment T_2 (80 %) and the least in treatment T_3 i.e. control group (73.7 %). But, the mortality was not due to feeding of *Bt* cotton seed. The ELISA of egg shell, egg yolk and egg albumen of eggs of layers of all the three experimental groups was found to be negative indicating there was no presence of *Bt* toxin in them.