ABSTRACTS
National Symposium on "Changing World Order-Cotton Research, Development and Policy in Context" at ANGRAU, Hyderabad (August 10-12, 2004)

PLANT BREEDING

1.1
Detection of genetic parameters for yield and its component characters in upland cotton (*Gossypium hirsutum* L.)

PARAMJIT SINGH AND G. S. CHAHAL
Punjab Agricultural University, Regional Research Station, Bathinda-151 001

The additive, dominance and epistatic components of genetic variation are estimated to understand the genetic architecture of quantitative characters to formulate an apporpriate breeding procedure to be followed. The experimental material consisting of different generations of Single tester analysis was grown in a randomized complete block design and was evaluated for characters related to yield and its component characters. The analysis of variance for the test of epistasis based on scaling tests A_i and B_i revealed the presence of epistasis for most of the characters studied. The additive genetic component, dominance genetic component, and their relative contribution towards genetic variation in the population were estimated. These results indicated the involvement of additive as well as non-additive gene action in the inheritance of various characters. The magnitude of additive genetic component was higher than dominance genetic component for number of monopods, average internodal length, number of bolls, number of fruiting points, boll setting percentage, days to maturity, harvest index whereas for number of sympods, plant height, yield of seed cotton per plant, boll weight and seed index, the magnitude of dominance component was higher and degree of dominance showed over-dominance.

1.2
Phenotypic stability for yield and its component traits in upland cotton hybrids

K. S. NIRANIA, B. S. CHHABRA, P. P. JAIN, YAGYA DUTT AND M. S. BHATTOO
CCS Haryana Agricultural University, Cotton Research Station, Sirsa-125 055

Cotton crop being highly sensitive to weather fluctuations, shows high magnitude of genotype x environment interactions. The present study, therefore, was conducted to identify stable hybrids amongst 48 hybrids based on genetic male sterility (GMS) for seed cotton yield and its component traits. The material for the present investigation comprised of 48 GMS based upland cotton hybrids and standard check HHH 81, grown at two locations *viz.,* Hisar and Sirsa for two years to provide four environments. The observations were recorded on seven characters related to plant morphology and seed cotton yield. Variance due to genotypes, environments and G x E interactions were significant for all the characters studied. Both linear and non-linear components were important for all characters. G x E (linear) portion was higher in magnitude than non-linear for number of monopods, number of bolls, boll weight, seed index and seed cotton yield whereas pooled deviation was higher for plant height and number of sympods. A major portion of G x E was accounted by non-linear component for plant height, number of sympods, whereas linear portion was higher in magnitude for number of monopods, boll weight, boll weight and seed cotton yield. No hybrid was suitable for all the characters studied. Top yielding hybrid IAN 579 xG 67 was found responsive for yield but was unstable. IAN 579 x A 72-15 and SA 278 x G 6030 were found desirable with non-significant bi and S^{-2} di values thus being more adaptive. Hybrid SA 278 x G 6030 was stable for most of the characters, except number of bolls.

1.3
Heterosis for seed cotton yield and its contributing traits in American cotton

K. S. NIRANIA, P. P. JAIN AND YAGYA DUTT
CCS Haryana Agricultural University, Cotton Research Station, Sirsa-125 055

Heterosis is an important breeding approach used for increasing the yield and other trait in crop plants. For commercial exploitation of heterosis, the magnitude of heterosis provides a basis for genetic diversity and is a guide to the choice of desirable parents for development of superior F_1 hybrids. The present experiment was conducted to study heterosis for seed cotton yield and its contributing traits. Sixty nine F_1s were developed in a line x tester fashion by crossing 23 lines with three testers. These F_1s were evaluated against standard check (H1117) in a randomized block design with three replications. The data were recorded on number of bolls/plant, boll weight, number of monopods, number of sympods and seed cotton yield/plant, and economic heterosis was determined over check (H-1117). The maximum heterosis for seed cotton yield was observed in the cross H 777 x HS 52 (27.68%), for number of monopods in the cross HS 6 x JP 9 (56.6%), for number of sympods (26.*%) in cross H 88 c F 846, for boll weight in cross HS 6 x Gumbo (28.7%), and boll number in cross H 777 x Delfos (26.9%). Other hybrids showing desirable heterosis for seed cotton yield were H 88 x ARB 9009 (25.00%), H 88 x HS 54 (24.32%), H 88 x HS 52 (21.36%), H 777 x Delfos (20.57%), H 777 x Machha Early (18.85%), and HS 6 x BJR 592 (17.85%). Most of the hybrids having desirable heterosis for seed cotton yield also showed significant heterosis for either of its component traits *viz.,* number of bolls/plant and/or boll weight. Hybrid H 777 x HS 52 might be exploited at commercial level after multilocational testing. Further, parents HS 52, HS 54, Machha Early, ARB 9009, BJR 592, Delfos and HS 54 could be utilized in cotton breeding programme including heterosis breeding breeding.

1.4
Suitability of *Gossypium arboreum* to Northern Telangana zone of Andhra Pradesh

S. NARENDER REDDY, P. SESHAGIRI RAO AND S. RATNA KUMARI
Acharya N. G. Ranga Agricultural University, Regional Agriculatural Research Station, Jagtial-505 327

A field experiment was conducted at RARS, Jagtial for three (2000-2002) *kharif* seasons to study the suitability of *arboreums* in comparison to other cotton species, *Gossypium herbaceum, G. hirsutum* and *intra hirsutum* hybrids in Northern Telangana agroclimatic zone. The yield and yield attributes, physiological and quality parameters of these genotypes were studied. Critical analysis of results revealed that among the four species tested, *arboreums* recorded significantly highest mean seed cotton yield of 1840 kg/ha, followed by *herbaceum* (1260 kg/ha). Among the *arboreum* genotypes MDL-2452 and MDL-2450 recorded 2037 and 2034 kg/ha seed cotton yield, respectively. On the other hand the *herbaceum* genotypes, Jayadhar and G. Cot 23 recorded 1512 and 1469 kg/ha seed cotton, respectively. Nevertheless, the *hirsutums* and hybrids ADB-39 and MECH-162 recorded highest seed cotton yield of 1441 and 1811 kg/ha, respectively. Plant height and number of nodes were high in *arboreum* and *herbaceums*. on the other hand number of sympodia per plant was high in *herbaceums* and hybrids. maximum specific lecf weight was observed in *herbaceum* and hybrids. Boll weight was maximum in hybrids, followed by *hirsutums* and the least in *arboreums*. This study enabled to recommend *arboreums* to this region with low input management and less risk under rainfed situation.

1.5
Exploitation of hybrid vigour in cytoplasmic genetic male sterility based single and three way crosses in cotton (*Gossypium hirsutum* L.)

U. G. PATEL, J. C. PATEL, D. H. PATEL AND K. G. PATEL
Gujarat Agricultural University, Main Cotton Research Station, Surat-395 007

The material for present study comprised of 28 GMS based single crosses and 28 three-way crosses as well as conventional single hybrid G. Cot Hy-10 as standard check. Thus, 57 hybrids were grown in a randomized block design with three replications at Main Cotton Research Station, Gujarat Agricultural University, Surat during *kharif* 2000-2001 season. The analysis of variance revealed highly significant differences among genotypes for all the characters under study. The mean performance of three-way crosses was significantly higher for seed cotton yield, number of bolls/plant and lint index over standard check G. Cot Hy-10. The mean performance of single crosses was significantly superior for lint index only over G. Cot. Hy-10. However, the mean performance of single crosses and three-way crosses showed non significant differences for seed cotton yield, ginning outturn and boll weight. Conversely the three-way crosses showed clear cut superiority over single cross for bolls/plant. However, lint index in single crosses was significantly higher than that of three-way crosses. The present study indicated numerical superiority of three-way crosses over single crosses for seed cotton yield.

1.6
A comparative study of reconstituted GMS based and conventional Asiatic interspecific hybrids G. Cot. DH-7 and G. Cot. DH-9

J. C. PATEL, U. G. PATEL, D. H. PATEL, K. G. PATEL AND B. G. CHHIMPI
Gujarat Agricultural University, Main Cotton Research Station, Surat-395 007

Diploid cotton hybrids are known for their inherent ability to resist major pests and diseases in addition to high GOT, low cost management and wide adapatability under rainfed condition. Keeping this in view intensive programme on the evolution of Hybrid-4 was initiated in diploid cottons also. The main constraint in the spread of diploid hybrids is the hybrid seed production. With the advent of stable genetic male sterile line (DS-5) it has become feasible to produce enough and pure hybrid cotton seeds with much ease in *desi* cottons. The genetic male sterility from DS-5 has been successfully imparted to Sujay and 4011, the female parents of G. Cot. DH-7 and G. Cot. DH-9, respectively. Utilizing the converted genetic male sterile lines, Sujay and 4011 as female, hybrid seeds each of G. Cot. DH-7 and G. Cot. DH-9, respectively were produced alongwith the corresponding conventional hybrids. The performance of reconsituted G. Cot. DH-7 and G. Cot. DH-9 were assessed against the conventional hybrids for two years i.e. 1998-99 and 1999-2000. Crossed boll setting was improved in converted genetic male sterile lines Sujay and 4011 as compared to normal lines. The performance of reconstituted hybrids was statistically *on par* with the conventional hybrids in respect of almost all the economical as well as technological characters studied which indicated an advantage of male sterility system over conventional method.

1.7
Variation and character associations in segregating generations of *G. arboreum* cotton

T. PRADEEP, S. LAXMAN AND K. SUMALINI
Acharya N. G. Ranga Agricultural Univeristy, Agricultural Research Station, Mudhol-504 102

Desi cottons belonging to *Gossypium arboreum* are reputed in trade for their tensile strength and consistent fibre properties. Owing to their wider adaptability and inherent ability to tolerate both sucking pests and bollworms they can be grown successfully with low input cost as against the *G. hirsutum* hybrids which are highly susceptible to pests and diseases. Therefore, it is necessary to promote the cultivation of *desi* cottons on

a large scale particularly among the poor farmers. However, due to limited genetic variability available in the cultivated diploid species, conventional breeding techniques have not given the desired results.Therefore, an attempt was made to evaluate the nature of genetic variability generated in three derived populations of two *intra arboreum* crosses following three different mating systems, namely, self, open and selective intermating in F3 generation. A comparison of the magnitude and nature of variability released in F4 generation and the effect of the mating systems in dissipation of undesirable linkages and changes in character associations was also studied.

Variability in segregating generations of two *G. arboreum* crosses as influenced by different mating systems was studied and compared in F4 generation. Both the crosses exhibited varied response specific to character and the mating system used to advance the generations. Reduced variability observed in both the intraspecific crosses for some of the characters in the populations advanced through either selective intermating or open pollination as compared to self pollination could be attributed to linkage disequilibrium. Significant changes in character associations were observed in F4 population of both *intra arboreum* crosses following three mating systems. Population raised through selective intermating in Mdl 2562 x PA 141 appears to provide good scope for the recovery of better segregants over the other two mating systems while open and self pollination provided similar advantage in Mdl 2556 x NA 2708.

1.8
Triallel analysis for number of monopodia and sympodia in upland cotton (*Gossypium hirsutum* L.)

S. LAXMAN, T. PRADEEP AND M. GANESH
Acharya N. G. Ranga Agricultural Univeristy, Agricultural Research Station, Mudhol-504 102

Cotton continues to maintain its importance as the most premier crop of commerce in our country. Pace of progress in breeding for quantitative traits depends upon the information available on the gene action governing the inheritance of the traits concerned and planning and execution of breeding programmes accordingly. Often epistatic effects are ignored leading to biased estimates. Triallel analysis provides information on all types of gene action *viz.,* additive, dominance and epistatic components, besides suggesting order of parents in three way cross combinations for obtaining superior transgressive segregants. In cotton, number of monopodia and sympodia are the important quantitative traits which determine the number of bolls/plant and ultimately seed cotton yield/plant. Hence, triallel analysis for number of monopodia and sympodia/plant was undertaken by using 60 three-way cross hybrids involving 6 parents in a triallel mating design to know the order of parents and gene actions involved in governing the inheritance of these two traits. For both the traits, the parent order effects in three way cross combinations were clearly elucidated. The epistatic components of gene action particularly dominance x dominance and additive x dominance played major role in expression of both of these traits. Dominance and dominance x dominance possessed opposite signs with each other for both the traits indicating role of duplicate type of gene action, which hinders the pace of progress of breeder in improvement of these traits. Hence, selective intermating in early segregating generations of single or multiple crosses has to be adopted for breaking gene constellations and release more transgressive segregants so as to achieve fruitful results.

1.9
Inheritance of elliptic boll shape in cotton (*Gossypium hirsutum* L.)

R. K. GUMBER, G. S. CHAHAL AND P. K. VERMA
Punjau Agricultural University, Cotton Research Station, Abohar-152 116

Quality seed has a significant contribution in boosting the production and productivity of cotton. A good quality seed should have higher genetic purity, germination, physical purity and must be free from any disease, weed and other crop residues. A number of morophological traits such as leaf color, leaf shape, flower and anther color and boll size and shape have been used to maintain the genetic purity of the seed of a particular variety or parents of the hybrids in Cotton. LHH 144 is the first American cotton hybrid which is immune to cotton leaf curl virus and has been developed and recommended for cultivation by the Punjab Agricultural University, Ludhiana. The female parent PIL 43 of this hybrid has okra leaves with oval shape large bolls.

whereas the male parent PIL 8 has normal green leaves and elliptic bolls. The F_1 hybrid (LHH 144) has oval shape bolls like the female parent PIL 43 indicating that the trait is recessive. The F_2 population of the cross PIL 43 x PIL 8 was grown in 10 rows plot of 6 m long during *kharif* 2003 to determine the number of genes controlling the elliptic boll shape. The rows were kept apart at 67.5 cm, while plant to plant distance was maintained at 75 cm. The recommended crop production practices were followed to raise a good healthy crop. The number of plants having oval and elliptic bolls were counted separately. The χ^2 test for the goodness of fit between observed and expected member of plants having elliptic and oval bolls were performed. The F_2 population of cross PIL 43 x PIL 8 segregated in the ratio of 3 oval : 1 elliptic bolls. Out of 79 plants, 24 had elliptic shape bolls, while the remaining 55 plants had oval bolls like that of PIL 43. Thus indicated that a single recessive gene controls the elliptic boll shape. The results will be confirmed by studying the F_3 progenies of this cross as well as F_2 populations of a large number of crosses involving the parent PIL 8.

1.10
Sustainability index as an aid for determining genotypic stability in cotton (*Gossypium hirsutum* L.)

B. D. SOLUNKE AND J. M. PATIL
All India Co-ordinated Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri-413 722

Development of varieties and hybrids with stable performance is gaining ground now a days to achieve sustainablity in agricultural production. The use of sustainability index in terms of varietal stability gives an indication about the stability of variety across the location and over the years. The present study was undertaken todetermine the sustainability index.

The experimental material consisting of thirteen *Gossypium hirsutum* cotton genotypes and check (JLH-168) was grown in randomized block design with two replications and was evaluated for three consecutive years from 1999 to 2001 at Cotton Improvement Project, MPKV, Rahuri. The three years data in each genotype were used for estimation of respective sustainable index. The yield differences were found to be significant over the three years indicating the genetic differences among the different genotypes used in the studies.

The genotype RHBB-9720 recorded highest yield of 14.72 q/ha. However, the sustainable index (47.82%) was low, indicating location specificity of the genotype. Similar trend of high performance (12.27 q/ha) and low sustainability index (58.51%) was recorded in the genotype RHBB-9713. The high level of yield coupled with high sustainable index was recorded in genotypes *viz.,* RHBB-9714, RHBB-9718, RHBB-9711 and RHBB-9719. The high level of best performance coupled with high value of sustainable index could be taken as the indication of closed proximity between the best performance and average performance over the years. Yield performance and sustainability index of remaining genotypes were poor to average. It was concluded that the genotypes RHBB-9714, RHBB-9718, RHBB-9719 and RHBB-9711 were more suitable and could be used as parents in future breeding programme for evolving genotypes with high sustainability of seed cotton yield.

1.11
Heterosis and combining for yield and its components in *Gossypium hirsutum* L. cotton

G. C. SHINDE AND A. S. MOKATE
All India Co-ordinated Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri-413 722

The present investigation was carried out at Cotton Improvement Project, MPKV, Rahuri to study heterosis and combining ability for yield and yield-contributing traits using diversified plant type. Studies made with seven genetically and morphologically diverse parents and their 21 F_1s revealed that almost all the characters, except boll weight, exhibited significant differences among the hybrids. Among the parents high GCA effects for seed cotton yield/plant were recorded by GISV-203, followed by IS-376/4/1 L-15. Besides having high GCA effects, the cross combination between these parents also showed high SCA effects and heterobeltiosis

for seed cotton yield/plant (194%) and number of bolls/plant (107.57%). Hence these combination may be exploited for getting transgressive segregations.

1.12
Heterosis in GMS based *intra arboreum* crosses of cotton

A. S. MOKATE AND H. N. SHINDE
All India Co-ordinated Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri-413 722

Diploid cotton hybrids have high degree of resistance to biotic and abiotic stress and wider adaptability. Hence, these can be successfully grown under irrigated and rainfed conditions. These are also resistance to leaf curl virus. However, the main constraint in the spread of cultivation is the problem of hybrid seed production due to poor hybrid seed setting. The present investigation was under taken to identify high yielding GMS based *intra arboreum* hybrids.

Eight genetic male sterility (GMS) based *intra arboreum* crosses were evaluated in randomized block design with two replication during 2003 at Cotton Improvement Project, Rahuri. Eight *arboreum* varieties were crossed with MPKV GMS line which was developed at Cotton Project, Rahuri. The heterosis was worked out over two varietal checks *viz.,* Y-1 and JLH-794 and three hybrid checks *viz.,* Swadeshi-1, 5 and G. Cot. MDH-11. The hybrid RAH-7 (1332 kg/ha) recorded significantly higher seed cotton yield than the rest of the hybrids and varieties. The other hybrids *viz.,* RAH-4 (1120 kg/ha) and RAH-8 (1097 kg/ha) produced significantly higher seed cotton yield over the check cariety Y-1 (767 kg/ha) and check hybrids Swadeshi-1 (760 kg/ha) and G. Cot MDH-11 (646 kg/ha). The hybrid RAH-7 recorded 52.40 and 46.53 per cent heterosis over check variety JLH-794 and hybrid Swadeshi-5, respectively. This study indicated the scope of utilization of heterosis of *intra arboreum* hybrid RAH-4, RAH-7 and RAH-8 for commercial exploitation.

1.13
Genetic diversity in introgressed lines of cotton

S. U. PARDESHI AND H. J. RAJPUT
All India Co-ordinated Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri-413 722

In the present investigation, genetic diversity was worked out for 46 introgressed lines of cotton obtained from different AICCIP centers for eight characters during *kharif* 2003 in randomized block design with two replications. The genetic distance between the introgressed lines was calculated as per Mahalanobis (1938) D^2 statistics. The genotypes were grouped into clusters using Tocher's Method as described by Rao (1952). The D^2 statistics showed that there was considerable divergence among the introgressed lines with D^2 values ranging from 0 to 25.50. On the basis of D^2 values, introgressed lines were grouped into 33 gene clusters. Out of these 20 clusters had single genotype which showed their genetic identity. A large number of clusters were formed due to the introgressed material. Clustering pattern of these introgressed lines did not follow the geographical distribution. At *intra* cluster level, the cluster 20 was the most diverse where as at inter cluster level, the clusters 30 and 33 were the most diverse. The characters contributing maximum to the divergence should be given more emphasis for the purpose of further selection and choice of the parents for hybridization.

1.14
Genetics of seed cotton yield in upland cotton (*Gossypium hirsutum*)

A. RAMALINGAM, P. AMALABALU AND N. SIVASAMY
Tamil Nadu Agricultural University, Cotton Research Station, Srivilliputtur-626 125

Six lines and their possible 30 hybrids generated through diallel fashion were evaluated for seed cotton yield. The results showed that the specific combining ability variance was higher than general combining ability variance, indicating the predominance of non-additive gene action for the inheritance of seed cotton yield. For exploiting non-additive gene action biparental mating system followed by recurrent selection was proposed. The genotype MCU 5, TCH 1002, SVPR 1 and Sharada were identified as good general combiner for seed cotton yield. the cross MCU 5 x TCH 1002, MCU 5 x Sharada and SVPR 1 x Sharada exhibited high heterotic

effects for seed cotton yield. In general, crosses with high *per se* performance yielded high *sca* effects and crosses involving at least one of the parents with either high *gca* or high *per se* showed high heterotic effect for seed cotton yield.

1.15
Heterosis in three way crosses of upland cotton (*Gossypium hirsutum*)

A. RAMALINGAM, P. AMALABALU AND N. SIVASAMY
Tamil Nadu Agricultural University, Cotton Research Station, Srivilliputtur-626 125

The yield level of many crops in general and cotton in particular have been improved in India by exploiting the potential of single crosses so far. Nevertheless, the rate of improvement can be accelerated through multiple crosses in this autogamous crop. Yield stability of multiple crosses particularly in three way cross was high under adverse environments, as demonstrated in crops such as maize and sorghum. This observation is particularly relevant to cotton which is usually grown under rainfed environments. Sixty three-way crosses involving six parents were evaluated in randomized block design. The mean data on seed cotton yield were analysed as per the triallel analysis model. The extent of heterosis, both over mid-parent (relative heterosis) and better parent (heterobeltiosis) in the three-way cross hybrids indicated significant heterotic effect in many three way crosses for seed cotton yield. The relative heterosis and heterobeltiosis values ranged from 1.8 to 154.7 per cent and -17.8 to 118.8 per cent, respectively for seed cotton yield. The three way cross hybrid (MCU 5 x SVPR 1) x JR 36 exhibited maximum relative heterosis and heterobeltiosis for seed cotton yield. The other promising three-way cross hybrids exhibiting significant heterotic effect for seed cotton yield are (MCU 7 x Sharada) x MCU 5, (MCU 7 x Sharada) x SVPR 1, (TCH 1002 x JR 36) x Sharada and (SVPR 1 x Sharada) x TCH 1002. The order effects of parents determined the performance and heterotic effects of the three way crosses. The triplet combination (MCU 5 x SVPR 1) x JR 36 showed the highest significant heterotic effect for both kinds of heterosis. The same parent involved in other two triplet combinations (MCU 5 x JR 36) x SVPR 1 and (SVPR 1 x JR 36) x MCU 5 gave non-significant heterotic effects.

1.16
RAJDH-9 an *intra arboreum* GMS based hybrid for Rajasthan

C. J. KAPOOR, B. S. MEENA AND P. PUNDHIR
Rajasthan Agricultural University, Agricultural Research Station, Sriganganagar-335 001

India is the pioneer country for commercial exploitation of heterosis in cotton crop in the world. At present, about 45 per cent of the total cotton area is being covered by cotton hybrids and their contribution is about 55 per cent to the national production. Hybrids are grown only on a small area (10-15%) in North Zone i.e. Punjab, Haryana and Rajasthan. Possible major constraints of hybrid adoption in North Zone are : (i) most of hybrids produced since 1970 were having long duration maturity period which do not fit well under North Zone double cropping system; (ii) severe winter in the Zone restrict the effective growing and fruiting period (15 August-15 September flowering, boll opening after 50-60 days restricted by low temperature was in November) (iii) the monsoon rains damage the early formed fruiting bodies; and (iv) cost of seed production is high in hybrids. Keeping in view the constraints the hybrid work under NATP-HCP project was initiated at Agricultural Research Station, Sriganganagar resulting in the development of GMS based *arboreum* hybrids RAJDH-9. The hybrid RAJDH-9 was tested in coordinated trials (1998-99 to 2001-02) SGNR, Ludhiana and at Hisar location. In North Zone the hybrid RAJDH-9 (2002 kg/ha) gave 7.22 per cent higher seed cotton yield over Zonal Check hybrid AAH-1 (1859 kg/ha) and has fitted well in cotton-wheat rotation. At Sriganganagar, the hybrid gave 11 per cent higher seed cotton yield over Zonal Check AAH-1 and 26 per cent over local check variety RG-8. The hybrid has 2.5% span length 19.2 mm and bundle strength g/tax at 3.2 mm gauge 19.0 and strength/length ratio 0.99. The hybrid RAJDH-9 is relatively less susceptible to root rot disease as compared to check variety RG-8 and RG-18. RAJDH-9 is also relatively tolerant to bollworms incidence as

compared to Zonal Check AAH-1 and local check variety RG-8. The hybrid has been released/identified by the State Varietal Seed Sub-Committee. Being Genetic Male Sterility hybrid, cost of seed production is Rs. 300.00/kg against conventional *desi* hybrid Rs. 700.00/kg at Sriganganagar.

1.17
A male sterile line of *Gossypium arboreum* cotton : RGMS-3

C. J. KAPOOR, B. S. MEENA AND P. PUNDHIR
Rajasthan Agricultural University, Agricultural Research Station, Sriganganagar-335 001

In *desi* cotton (*Gossypium arboreum*) only Genetic Male Sterility has been used in the development of hybrids. In order to diversify male sterile line in *arboreum* cotton, a germplasm line AC-6 was converted into genetic male sterility using GMS-1 as a source in backcrossing programme. RGMS-3 GMS line (*G. arboreun*) has open canopy, wider adaptability and resistance to root rot. The newly developed RGMS-3 line showed segregating of 50 : 50 in sterile : fertile ratio at Sriganganagar. The morphological features of RGMS-3 are flower colour creamy, leaves shape narrow, leaves colour green, ginning out turn 35.60 per cent, boll weight 2.55 g and seed cotton yield of 2148 kg/ha. The line has good general combining ability and is being utilized for the development of future GMS based *arboreum* hybrids. NBPGR, New Delhi registration No. of line is IC 296646.

1.18
Studies on genetic divergence in American cotton (*Gossypium hirsutum* L.)

L. SASI KIRAN, A. NARISI REDDY AND S. NEELIMA
Acharya N. G. Ranga Agricultural University, Regional Agricultural Research Station,Lam, Guntur-522 034

One hunderd genotypes of American cotton (*Gossypium hirsutum* L.) were grown under rainfed conditions during 2002-03 crop season at Regional Agricultural Research Station, Lam. These were subjected to multivariate analysis to study the gentic divergence. The genotypes were grouped into 14 clusters based on the individual D2 values of the characters *viz.,* days to 50% flowering, number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight (g), number of seeds per boll, seed index (g), lint index (g), ginning percentage, 2.5% span length (mm), micronaire (10-6 g/in), maturity coefficient, uniformity ratio, bundle strength and seed cotton yield per plant (g). Clustering pattern of the genotypes did not follow geographical origin, suggesting that geographical isolation may not be the only factor causing genetic diversity. Cluster I had the highest number of genotypes, followed by cluster II. The inter-cluster distance ranged from 7.80 (between clusters I and VII) to 14.77 (between VIII and XIII). Of the 15 characters studied, bundle strength followed by seed cotton yield, number of sympodia per plant, 2.5% span length and uniformity ratio contributed maximum towards genetic divergence. The genetically diverse parents were likely to produce not only high heterotic effects but also desirable segregants. Useful recombinants in the segregating populations could be obtained by making crosses between genotypes of clusters X (LAHH 4 M, Empire glandless) andXIV (RAC 9561) and also between VIII (MCU 2, Tx Maroon) and XIII (TKH 1175) as the distance was maximum between clusters.

1.19
Combining ability on quantitative components in upland cotton

N. R. POTDUKHE AND J. N. PARMAR
Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola-444 104

Combining ability studies conducted for eleven yield contributing traits in upland cotton revealed that the parent PKV Rajat, Khandwa-2 and JLH-168 for plant height; G. Cot-16 and Surbhi for number of monpods;

Surabhi, Khandwa-2 and Vikram for number of sympods; JLH-168 and L-604 for boll number as well as fruiting points; G. Cot-16 for lint index; Surabhi for 2.5 per cent span length were the best general combiners. These parents could be used for developing either F_1 hybrids or synthetics and for isolating high yielding pure lines with desirable agronomical characters. The hybrids Sahana x Vikram, JLH-168 x Surabhi, JLH-168 x Vikram were found tobe commercially exploitable after multiple testing.

1.20
Line x tester analysis for yield and yield contributing traits in *Gossypium arboreum* L.

P. S. NAPHADE, R. P. KHARDE, J. N. PARMAR, N. R. POTDUKHE AND B. R. PATIL
Cotton Reseach Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola-444 104

A study was conducted in a line x tester (6 x 3) model to assess the combining ability effects and heterosis for plant height, number of monopodia, sympodia, bolls per plant, seed cotton yield, boll weight, seed index, ginning outturn and lint index in *Gossypium arboreum* L. The estimates of *gca* indicated that line AKA-8616 was a good general combiner for plant height, lint index and ginning outturn and the tester AKA-9124 a good combiner for seed cotton yield, seed and lint index. As regards the heterosis, number of bolls per plant had high extent of heterotic response, moderate response for number of sympodia and boll weight, marginal for seed index and low for ginning outturn and lint index. The cross GAM-87 x AKA-9124 exhibited highest sca estimates.

1.21
Generation of new germplasm in cotton through interspecific hybridization using wild species

S. S. NARAYANAN AND V. SANTHANAM
Agricultural Reseach Service (ICAR) Retd. and Conslutant (Cotton) Secunderabad-500 009

Hutchinson (1959) postulated that wild diploid species such as *Gossypium anomalum* and *G. raimondii* have themselves played a role in the evolution of the cultivated diploid species *G. herbaceum* and the cultivated allo-tetraploid species (*G. hirsutum*), respectively. The variation inherent in several diploid wild species of *Gossypium* has fascinated cotton breeders to explore the potential for incorporating desirable genes into the tetraploid cultivated cottons for broadening the genetic variability. Latent potentialities reported in certain wild diploids for imparting lint fineness, fibre strength and maturity of fibres besides ginning outturn into the cultivated cottons are of great economic importance in meeting the new needs of the textile industry. However notwithstanding the all-out efforts made in the last century, much tangible achievement could not be made and this is party because of frustratingly long gestation periods required in such research and the lack od continuity in cytogenetic and introgressive breeding efforts.

The possibility for incorporating certain technological properties of value from selected wild species was explored at the Cotton Breeding Station, Coimbatore. *G. anomalum* for improving the fibre fineness, strength and maturity, *G. amourianum* for lint strength and increased number of ovules per locule and *G. raimondii* for increasing the fibre length, fineness and strength besides ginning outturn were identified for intersepecific hybridization with the two cultivated diploids *G. herbaceum* and *G. arboreum* as well as with the cultivated tetraploid cottons *G. hirsutum* and *G. barbadense*. The selected diploid hybrids and the triploid hybrids produced were raised to the allotetraploid and allohexaploid levels, respectively by suitable colchicine treatment.

These induced amphiploids at allotetraploid level and the allohexaploid level were backcrossed to the respective cultivated parents MCU 5 (*G. hirsutum*) and Sujatha (*G. barbadense*) as they were also used initially as the best fibre quality parents of the two tetraploid cottons.

The allotetraploid progenies up to A 4 (amphiploids) and also certain backcross progenies of the trispecies hybrids were also evaluated for cyto-genetical behaviour and breeding potential. Very interesting phenotypic variability was witnessed for several plant attributes in the progenies screened.

Observed range in technological properties :
2.5% span length (mm) : 30.8 to 32.0 (check 29.1), bundle strength tenacity (g/tex) : 48.2 to 52.2 (check 46.4), lint index (dg) : 52-61 (check 46), mv : 3.2 to 4.0 (check 3.4), ginning outturn percent : 35-39 (check 31 and 34), plant type : compact to semi-compact with good boll shape and size, petal spot in certain derivatives involving hirsutum parent.
In the straight and modified (self-fertilized progenies/generations of induced amphiploids) allotetraploid methods, introgression was observed for genes for leaf hairiness and fibre quality in the backcross Bc 1F2 in the cross involving *G. hirsutum* with *G. anomalum* and for leaf lobe type, leaf hairiness, compact plant habit, improved boll number, ginning, fibre fineness and strength in the cross involving *G. barbadense* with *G. anomalum*. In the backcross made from the allophexaploid technique, introgression for higher ginning, fineness, maturity coefficient and seed index was observed in certain derivatives involving *G. raimondii*. More than a hundard inter-specific derivatives involving three species were added to the primitive selections gene pool at Coimbatore for further evaluation and utilization in cotton improvement. The differential role of allotetraploids and allohexaploid techniques as well as the role of self fertilized generations of induced allotetraploids and the backcrossing and *inter se* mating have been identified as useful approaches from the studies.
In the Mini-Mission-I of the Technology Mission on Cotton (TMC) and National Agricultural Technology Project (NATP) under operation, inter-specific hybridization work involving wild species has been undertaken in the last four years and as the scope for building up new and variable gene pool is great, the material should all be brought under a coordinated evaluation and conservation system at a common place like Central Institute for Cotton Research, Nagpur even after the TMC or NATP ceases to support such work after a given period.

1.22
Complexities in *Gossypium* genome evolution and need for re-examination of the intricate cytogenetic relationships between different species genomes

S. S. NARAYANAN AND V. SANTHANAM
Agricultural Reseach Service (ICAR) Retd. and Conslutant (Cotton) Secunderabad-500 009

Biotechnology has emerged as a potent additional tool for crop improvement. The increasing global interest shown in establishing institutions and international collaborative projects for structural and functional genomics including bio-informatics for the development of fully integrated genetic and physical map of the cotton (*Gossypium*) genomes and gene discoveries for improving the fibre quality of cotton to changing needs have necessitated new initiatives in all aspects of cotton research.
Cotton is facing severe competition from man-made fibres and the textile industry armed with the fastest and sophisticated spinning, weaving and knitting machinery has been demanding new priorities in cotton fibre and emphasis is now given on increased strength micronaire value, elongation and maturity of the fibre besides fibre length with low short fibre content and high length uniformity. The conventional breeding approaches have made much headway in cotton fibre quality improvement over the whole of the 20th century, but more prioritized tools like hybrid cottons and *Bt*-based transgenic hybrid cottons in India have created a situation requiring better balancing of yield with fibre quality for sustainable cotton production and meeting modified consumer demands.
The cultivated amphidiplod species of *Gossypium* are considered to be of monophyletic origin except for similar segmental arrangement from the studies so far made. The basic chromosome number is inferred as 13 based on the occurrence of quadrivalents in the Old World and New World cotton hybrids and is supposed to have arisen by modified tetraploidy.
Gossypium is an interesting alloploid genus with a wide diversification of species at diploid as well as tetraploid levels. Its continuous evoluation over several millennia is characterized by rare interplay of evolutionary forces like inter-specific hybridization in nature species migration, polyploidy, cryptic structurasl differentitation, preferential pairing, introgressive gene exchanges especially between the two diploid cultivated and between the two tetraploid species, gene mutations changing naked seed to lintedness, liberal

gene flow, cyptoplasm diversification and very skillful manipulation in the form of human selection. In view of the importance gained in the cultivation of the two-allotetraploid cottons on a global scale over the last few centuries and continental migrations, it had also added to high gene introgressions benefiting both the species.

Cyto-genetical studies of the 20th century in USA, India and other countries laid the foundations for better understanding of the genomes of *Gossypium* that are now identified into AA, BB, CC, DD, EE, FF, GG, and 2 (AD). According to Brown (1954) pachytene pairing in hybrids cannot be considered as a measure of chromosome or species differentitation. Metaphase pairing still continues to be the best criterion of chromosome homology since chiasma formation appears to be very important in determining the chromosome homologies in species hybrids. For some decades at least, the study of cytogenetics had been given less attention and now it is an opportune time for reopening the studies afresh to get a new insight.

Multiple gene substitutions and structural differentitation besides gross structural differenced hsve been brought out in the Genus and major segmental interchanges rather than polyploidy alone seems very important. Wild non-lint bearing species have n=13 chromosome and certain semi-wild allotetraploid species with n=26 and are extensively differentiated so that the species of the various continents and within groups have a characteristics genome and low pairing between them. Gross structural differences have been reported in the B, C and D genomes as evidenced from meiotic studies. Limited inter-specific polymorphism for DNA in *Gossypium* species for most marker types bring out the complexity and size of the tetraploid cotton genomes i.e., moderately large amount of DNA, many chromosomes, very high recombination and polyploid (paleo-octoploidy) etc.

The genome analysis of plants and sequencing studies might reveal large number of duplications and the presence of a large function of sequences as transposable retroelements of different kinds with which the genomic complexity and functional complexity could be explained along with their implications in genomic expansion during evolution.

In the wide array of *Gossypium* genomes identified in different species, there are answers, both hidden and explicit, to many of the much-needed agronomic and technological problems in cotton production and utilization and with the help of reassessment of cyto-genetic attributes in the genus, it would be possible to find sustainable solutions from within the genera itself through genetic engineering for making rapid strides. The ability to look at genomes wide expression of genes will throw open the possibility for transferring useful genes from different members within the genera that are confornted with sterility and species barrier problems in conventional approaches. Such a reexamination of the cytogenetic and DNA sequences will enlarge our approach to structural genomics, functional genomics, comparative genomics, proteomics, transcriptomics and bio-informatics for more effective planning of our biotechnological and genetic engineering approaches to cotton improvement with priority for fibre quality.

1.23
Estimation of heritability by parent-progeny regression method in coloured cotton genotypes

D. PUNITHA, T. S. RAVEENDRAN AND R. RAVIKESAVAN
Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University Coimbatore-641 003

The broad sense heritability values estimated in conventional breeding methods appear to be too high and did not get reflected in the expected response to selection. Since there was no parallel method of estimating heritability, the parent-progeny regression method appeared to be more realistic. In the present investigation, heritability was calculated by the parent-progeny regression method, using the mean expression of seven coloured cotton crosses for F_2, F_3, F_2M_2 and F_3M_3 generations. The narrow sense heritability estimated by the parent-progeny regression method was low as compared to the heritability values calculated by the components of variance method. The fixable part of variation due to additive gene action was found to be more within the segregating lines of irradiated generations than in the non irradiated generations. Moreover, broadening of genetic variance in hybrid populations occurred as a result of irradiation, though it was not uniform in magnitude in respect of all the charactes. Heritability values for number of sympodia/plant and boll weight based regression values of F_2M_2 and F_3M_3 generations were 30.30 and 55.92 which were recorded in

the Algerian brown x MCU 7. High heritability of 21.91 and 25.63 per cent for yield of seed cotton and boll weight, respectively were recorded in the cross Nankeen brown x MCU 9 (F_2M_2-F_3M_3). The heritability values were pronounced in the irradiated populations of crosses Algerian Brown x MCU 7, Nankeen brown x MCU 9 and Parbhani American x MCU 5 for yield, yield components as well as fibre quality parameters besides lint colour and lending these populations amenable for selection.

1.24
Study of heterosis in CMS based *intra hirsutum* hybrid in cotton (*Gossypium hirsutum* L.)

O. P. TUTEJA, SURENDER KUMAR, SUNIL KUMAR AND MAHENDER SINGH
Central institute for Cotton Research, Regional Station, Sirsa-125 055

Cotton is an important cash crop of the world. Cotton fibre is the most important raw material for the textile industry as it accounts for more than 80 per cent of all textile fibre consumed by the Indian textile industry. India became the pioneer country in the world in 1971 when Dr. C. T. Patel released the first hybrid H 4 and successfully exploited hybrid vigour in cotton on commercial scale by using the conventional technique of hand emasculation and pollination. Conventional hybrid seed production in cotton is not feasible in north zone because of high wages of labour, short duriation of flowering period (40-50 days) and boll-setting period coinciding with cloudy weather in comparison to central and south zone. Keeping these views into consideration, development of the hybrids based on cytoplamic male sterility (CMS) was undertaken as this system is more convenient and useful than conventional system of hybrid seed production. Reduction in cost of hybrid is possible only by the use of male sterility.

Twenty cytoplamic male sterile lines (CMS) of American cotton (*Gossypium*) were converted by using the cytoplasm of *G. harknessii* and used as a female parent. On the other hand different CIR lines *viz.* CIR 19, 12, 1, 15, 16, 9, 7, 8, 56, 23, 26, 1, 32, 70, 72 and CIR 142 were used as a male parent and crossed during *kharif* 2002-03 and 2003-04. As many as 15 and 16 crosses out of different possible combinations were grown during *kharif* 2002-03 and 2003-04, respectively in a randomized block design at Central Institute for Cotton Research, Regional Station, Sirsa. Heterosis for yield and fibre properties was estimated in 16 CMS hybrids during 2002-03 and 15 CMS hybrids during 2003-04. Standard heterosis over conventional check 'Om Shankar' was estimated. In the first set, none of the CMS hybrids showed significant heterosis for seed cotton yield, boll number per plant and 2.5% span length. However, in the second set, two crosses *viz.* SPC58 x CIR 32 and CMS 16 x CIR 70 recorded significant positive heterosis of 39.11 and 56.50 per cent, respectively. The increase in seed cotton yield was mainly due to increase in number of bolls/ plant. These crosses also recorded significant positve heterosis for number of monopods per plant and boll weight. For ginning outturn two crosses recorded 36 per cent (CMS 16 x CIR 70 PSCC) and 35% (CMS 16 x CIR 70 CC) in comparison to 33 per cent in the check hybrid Om Shankar.

1.25
Studies on combining ability for yield and quality traits in cotton (*Gossypium hirsutum* L.)

S. K. VERMA, O. P. TUTEJA, S. L. AHUJA, N. R. KOLI AND D. MONGA
Central institute for Cotton Research, Regional Station, Sirsa-125 055

The present investigation was carried out with an aim to study the combining ability for yield and quality tratis in *Gossypium hirsutum* L. A set of 7 parents and their 21 F_1 hybrid were evaluated in RBD with three replication in diallel fashion at Central Institute for Cotton Research, Regional Station, Sirsa during *kharif* 2003-03 for yield and its related traits. Five random plant from each entry per replication were selected and data were recorded for yield (kg/ha.), number of bolls per plant, boll weight (g), ginning out turn %, staple length, micronaire value and bundle strength (g/tex.). The pooled analysis of variance for combining ability revealed that mean squares due to GCA and SCA were significant for all the traits, except boll weight, GOT

(%) and 2.5% staple length in the study. This indicated that both additive and non-additive type of gene action were important in the inheritance of yield and its related traits. Out of seven parents, the parent (CISV-12) was adjuged the best general combiner as it depicted high GCA effect in desirable direction for most of the traits. Regarding SCA effects, cross CISV-47 x CISV-12 showed the highest SCA effects for yield (kg/ha), GOT (%) and strength (g/tex) and cross CISV-47 x CIT (7-2) showed the highest SCA for number of bolls/plant.

1.26
Screening of *desi* cotton (*Gossypium arboreum*) germplasm for shattering resistance

R. A. MEENA, D. MONGA, RAJIVE KUMAR AND VEER SINGH
Central Institute for Cotton Research, Regional Station, Sirsa-125 055

Cotton, the most important commercial crop of the country, is grown in 15 lakh hectare in north zone out of which *desi* cotton (*Gossypium arboreum*) consititutes around 25 per cent area. The *desi* cottons are having very high yield potential along with resistance to biotic and abiotic stresses. The yield potential of some *desi* cotton varieties is noticed up to 40 q/ha which is much higher than *G. hirsutum.* However, inferior fibre properties and poor locule retentivity are the major drawbacks in *desi* cotton. The seed cotton after opening of bolls fall down on the ground within a short duration creating problem in its picking. As a result of this, several types of impurities combine with lint which hinder its processing. The problem is further aggravated due to adverse weather in the form of high wind, rain and hail storm. Five hundred and forty lines of national gene pool of *G. arboreum* cotton were evaluated for good locule retentivity under north zone conditions at CICR, Regional Station Sirsa for three years (2001-03) using recommended package of practices. Sixty nine genotypes with more than 80 per cent boll retention capacity were identified out of which eight lines PA 255, CISA 196, CISA 290, CISA 334, CISA 338, CISA 342, 6637 and AC 3088 were completely resistant to shattering. In addition to good locule retention capacity, the cultivar CISA 290 showed higher boll number (45.5) and good yield potential (113.8 gm/plant), followed by cultivar CISA 196 (boll number 39.5, yield 90.9 gm/plant) and CISA 342 (boll number 35.5, yield 85.2 gm/plant). These lines can be utilized as such or for incorporating shattering resistant character through breeding program in *desi* cotton cultivars.

1.27
Path analysis in upland cotton (*Gossypium hirsutum* L.) under unprotected condition

R. K. PATNAIK, P. SIAL, D. J. BAGE AND S. A. PATIL
Department of Genetics and Plant Breeding, Univeristy of Agricultural Sciences, Dharwad-580 005

Sixty six hybrids along with their twelve bollworm tolerant parents of upland cotton, including commercial checks DHH-11, NHH 44 and Savita, were evaluated in R. B. D. with two replications during *kharif* 1998-99 at Main Research Station, Dharwad. Path-coefficient analysis revealed that lint yield, boll number, plant height and sympodia per plant were the most important attributes determining seed cotton yield, whereas boll number, ginning outturn and seeds per locule were the major determinatns for improving lint yield. Reproductive parts dry weight at 180 DAS and sympodia per plant were the most important traits for selecting varieties/hybrids with high boll number per plant.

1.28
Character association in American cotton (*Gossypium hirsutum* L.) under natural bollworm infestation

R. K. PATNAIK, P. SIAL, D. J. BAGE AND S. A. PATIL
Department of Genetics and Plant Breeding, Univeristy of Agricultural Sciences, Dharwad-580 005

Twelve bollworm tolerant genotypes along with their sixty-six hybrids, including commercial checks DHH -11, NHH -44 and Savita, were evaluated in R. B. D. with two replications at Main Research Station, Dharwad during *kharif* 1998-99 under unprotected condition. Highly significant positive correlation was observed among tannin content in boll rind, total dry matter at 60, 120 and 180 DAS reproductive parts dry weight at 120 and 180 DAS, leaf area at 60 and 120 DAS, internodal distance, sympodia per plant, seeds per locule, harvest index, locules per boll, seed index, ginning out turn and lint index with seed cotton yield. These traits could be utilized to develop high yielding hybrids/varieties with bollworm tolerance for an IPM system.

1.29
Stability of performance of interspecific cross derivatives of cotton over environments

K. G. PATEL, U. G. PATEL, R. B. PATEL AND B. G. CHHIMPI
Gujarat Agricultural Univeristy, Main Cotton Research Station, Surat-395 007

The present investigation was carried out to study the G x E interaction and stability of performance of interspecific cross derivaties of cotton over five locations *viz.,* Surat, Bharuch, Thasra, Dhandhuka and Porbandar in Gujarat during *kharif* 2002-03. The pooled analysis of variance revealed significant variation among genotypes as well as locations. Highly significant differences also existed for location. The differences due to genotype x location were not significant. However, significant differences were observed for genotype x location indicating linear response of genotypes to changing environments. The genotypes GISV-2 and GISV-3 possessed higher seed cotton yield than superior check G. Cot-16 coupled with bi equal to near unity and least derivatives for regression indicating stable and well adapted genotypes to all environments. GISV-203 and GISV-206 recorded high mean than population mean with regression near unity with least deviation from regression indicating their stability for seed cotton yield. Genotype GISV-61 though recorded higher mean yield, showed significantly higher coefficient of regression (<1) indicating good adaptation to favourable environment condition. Conversely, GISV-105 though recorded higher yield with bi equal to unity, showed very high value for derivation from regression. The performance of this genotype could not be predicted across environment.

1.30
Narasimha-an elite cotton variety for Andhra Pradesh

S. BASHA MOHIDDIN, Y. RAMA REDDY, AND P. RADHIKA
Acharya N. G. Ranga Agricultural University, Regional Agricultural Research Station, Nandyal-518 502

In Rayalaseema district of Andhra Pradesh cotton is grown in an area of 1.6 lakh hectares with a production of 3 lakh bales. About 70 per cent of the cotton area is under rainfed conditions. At Nandyal centre, which caters to the needs of cotton growers, as a result of intensive hybridisation and selection programmes, an improved Variety NA-1325 was isloated and evolved. It is a cross derivative of LRA-5166 and NA-1192 which in turn possesses PRS-72 (compact type), A-179 (high ginner) and Type -6-6 (jassid tolerance). This was released in the name of Narasimha. It is a short duration variety with an average yield of 2531 kg/ha as against 1605 q/ha of LRA -5166, registering 26 per cent increased yield over the check. This elite variety is having creamy petals and buff pollen ith capacity for rejuvenation even after adverse seasonal conditions, possessing good fibre

length of 26.0 mm and 38 per cent G. P. In addition to this, it is also suitable for cultivation with integrated pest management practices, since it is tolerant to jassid and bollworms. Narasimha, by virtue of its good combining ability, is widely utilised by cotton breeders as a parent in hybrid development programmes. It is not only spreading fast in Karnataka and Maharashtra states but also making a dent in neighbouring countries. This variety is very popular with the farmers of Andhra Pradesh because of its rejuenation capacity and assured net returns clinching the pride of place in cotton cultivation.

1.31
Collection and evaluation of genetic diversity in cotton under the National Agricultural Technology Project

V. V. SINGH AND S. J. BAITULE
Central Institute for Cotton Research, Nagpur-440 010

Genetic diversity is not a stagnant tool due to various natural and man-made factors causing new variations on a scale and magnitude that ae measurable and assessable through genetic and breeding tests. Therefore, continuous enrichment of the gene pool of cotton is an essential and integral part of maintenance of Germplasm Banks for crop improvement through systematic exploration of selected areas and collecting land races and mutant forms, besides other genetic stocks. Under the National Agricultural Technology Project (NATP) on plant biodiversity (cotton), the Central Institute for Cotton Research (CICR) at Nagpur in collaboration with the National Bureau of Plant Genetic Resources (NBPGR) explored several potential regions within India during 1999-2004 and collected certain germplasm about which information is provided here.

The regions explored and surveyed for collection of cotton germplasm included Malwa tract of Madhya Pradesh, Banswara region of South Rajasthan, tracts in Meghalaya, Melghat in Maharashtra, some semi-arid tracts in Karnataka, Jharkhand state, selected coastal tracts of Andhra Pradesh, coastal area of Saurashtra in Gujarat, and parts of Mizoram, Assam and Eastern zone of Orissa.

These regions represented almost the major part of India with varying soil and agro-climatic variations of a tropical to semi arid and sub-tropical areas and zones in which cotton had been/and is being cultivated over centuries, particularly the two Asiatic species of *arboreum* and *herbaceum* and also some *hirsutum,* besides land races and backyard perennial types in a scattered manner. A total of 576 accessions were collected, which represneted the above type, besides a few *barbadense* type perennials. The collections were made from diverse locations and environments such as high altitudes of upto 1200 meters in the N. E. states, salt and drought affected soils and regions, and other regions with ecological variations. Some of the accessions were from abiotic and biotic stress pockets of Central India, while others were finer versions of *herbaceum* staple and fibre, semi-open to closed boll type, tree-like and climbing habit types of *barbadense,* early harvest Asiatic types, non-shedding of loculi on burst bolls, long and heavy sized bolls with high ginning outturn and high seed number per boll, some semi-naked seeded, etc. While collecting these samples from standing crops and isolated plants, several of them appeared to bear high boll load under natural envionments in which they were identified. The samples were collected and added to the National Gene Bank at CICR, Nagpur and part of the seed samples for posterity in NBPGR Germplasm Conservation System. These were grown for checking for various attributes and seed multiplication at the CICR Experiment Farm.

Though a certain amount of these attributes are also recorded in earlier collections at the CICR Gene Bank, the combinations of attributes, genetic diversity and morpho-physiological paramerters of the new collections will enrich the Gene Bank. The genetic diversity among the collections within each of the species was wide, as judged by the various parameters in the Nagpur conditions.

1.32
An assessment of robust and compact plant genotypes under irrigated condition

PRAMOD ROKADIA AND SANJAY K. KAUSHIK
Maharana Pratap University of Agriculture and Technology, Agricultural Research Station, Banswara-327 001

A field experiment during 2002-03 was conducted at Agricultural Research Station, Banswara to find out optimum spacing for compact and robust cotton genotypes under irrigated condition. The experiment was conducted in two sets of spacing (90 x 45 and 90 x 30 cm) in RBD with six American cotton genotypes. Compact genotype RB-517 exhibited *on par* yield levels in both the spacings. The reduction in intra row spacing from 45 to 30 cm reduced the seed cotton yield. The robust genotypes exhibited higher negative response towards reduced spacing.

1.33
Structural variation in gossypol glands in *Gossypium arboreum* germplasm lines

PUNIT MOHAN, P. SINGH AND D. K. AGARWAL
Central Institute for Cotton Research, Nagpur-440 010

Gossypol glands are one of the important key characters used to define the tribe of family Malvaceae. Gossypol is biologically a toxic group of secondary plant metabolites and major constituent of gossypol glands and important potential source of natural resistance to insect pests of cotton. A study was conducted with 13 germplasm lines of *Gossypium arboreum* belonging to the three races *bengalense* (7), *indicum* (4) and *cernuum* (2). The crop was raised during 2001 and 2002 *kharif* season at Main Research Farm of CICR, Nagpur. At peak squaring and flowering stage, a set of leaf, flower bud and fertilized flowers were collected at uniform age and preserved in FAA (Formaldehyde, Acetic acid, Alcohol) solution for morpho-anatomical observations. The processing and staining of sections was done as per the procedure descrobed by Johnsen (1940) and midified by Meek and Elder (1977). Observations were recorded under binocular microscope.

Anatomically, gossypol glands were composed of lysigenous intercellular space in the form of large centrl cavity, surrounded by a single layer of flattened epithelial cells. These glands were designated as holocrine glands. At the initial developmental stage, the primary tissue lacked symmetrical arrangement and secondary tissues might also lose their symmetry. Further, a group of cells formed an intercellular space. Such spaces varied in shape and size with the shape and arrangement of the surrounding cell. These spaces were developed by the disintegration of cells form cavity. Glands were observed in disingtegrated or burst parenchymatous tissue of vegetative and reproductive parts *viz;* leaf bracteole, calyx, petal, ovary, stigma and style surface in 13 germplasm lines of *G. arboreum*. However, glands were embedded on the pitted surface of ovary and young bolls. The gossypol glands were spherical in shape on leaf bracteole, ovary and cotyledonary surfaces, elliptical on stigma and style surfaces and spherical to oval on stigma and style surfaces and spherical to oval on calyx surface in the above germplasm lines. However, the magnitude of structural variability in spherical glands on various plant parts ranged from 32.29 µ to 210.71 µ.

The elliptical glands were the largest 260.56 µ x 110.13 µ (length x width), followed by oval glands 251.21 µ x 198.53 µ (length x width), while the spherical glands (30.63 µ x 83.57 µ) were the smallest. Glands size was the largest on stigmatic surfaces (268.54 µ) and lowest on ovary and bracteole surfaces (42.13 µ).

Wide variability in size of glands on surfaces of various plant parts was observed among genotypes of three races of *G. arboreum,* namely, *bengalense, indicum* and cernuum. The glands size was signifiacantly and positively correlated with glanded area (volume). This investigation indicated valuable information on genotypic differences in gland structure and glandular area on the surface of various plant parts.

1.34
Locule retentivity in *Gossypium arboreum*

PUNIT MOHAN AND P. SINGH
Cenral Institute for Cotton Research, Nagpur-440 010

Gossypium arboreum L. is a native of India, and is cultivated in about 25 per cent of the total area in India, contributing about 18 per cent to the total production. Shedding or scattering of locules from the fully opened mature bolls is a serious problem in most of the varieties of *G. arboreum*. Fifteen cultures of *G. arboreum* combining earliness, big boll size, high fibre strength, medium and superior medium staple, locule retentivity and high ginning percent were developed at CICR, Nagpur. Nine advanced promising cultures were selected and grown under rainfed condition during 2000, 2001 and 2002 at main research farm of CICR, Nagpur. The locule holding capacity and period was observed in completely opened and bursted capsules. The seed cotton loaded locule holding period was higher in culture CINA 316 (18 days), CINA 318 (22 days) and CINA 324 (22 days). However, short period for locule retention was observed from 5 to 9 days in culture CINA 303, CINA 305, CINA 319, CINA 321, CINA 322, CINA 327 and check AKA 8401.
Simultaneously, placental anatomical studies were also conducted. Unopened flower buds were tagged with date. After fertilization, the modified ovaries (nascent capsules) were collected at the age of 10 days to maintain uniformity in age. Nascent capsules were preserved in FAA (Formaldehyde, Acetic acid and Alcohol) solution for anatomical studies. Transverse sections and longitudinal sections of placenta were studied under binocular microscope. The number, area and distribution pattern of vascular supply was observed by using colour filters and grid. Colour photography of important variants was done. The area was calculated on the basis of mean values of multiplication product of length and breadth and expressed in microns (μ^2). Double vascular supply was observed from placental region to locular compartment in culture CINA 316, CINA 318 and CINA 324 while culture CINA 303, CINA 305, CINA 319, CINA 321, CINA 322, CINA 327 and check AKA 8401 were coupled with single vascular supply. Thick walled cells of collenchyma (3-4 layers) were observed in the periphery region of placental compartment. With the gradual increase in age of capsule, these double vascular supply converted into thread like structures and make unbroken attachment between basal portion of placenta and seed cotton loaded capsules. However, single vascular supply into placental region in culture CINA 303, CINA 305, CINA 319, CINA 321, CINA 322 and check AKA 8401 revealed same mode of conversion along with single thread like structure. The above study indicated that double vascular supply from placenta to locular region provided high locule retentivity in *G. arborium* cultures. Locule retentives cultivars helped in reducing the pre- harvest seed cotton loss due to adverse weather in the form of high wind, rain and hailstorm. The source of locule retentivity in the race *cernuum* is available and being utilized for further improvement of *G. arboreum.*

1.35
Genetic divergence studies in introgressed lines of *desi* cotton (*Gossypium arboreum* L.)

J. S. V. SAMBA MURTHY, N. CHAMUNDESWARI, K. SUMALINI AND K. V. KRISHNA RAO
Acharya N. G. Ranga Agricultural Unviersity, Regiona Agricultural Research Station, Lam, Guntur-522 034

Nature and magnitude of genetic divegence was assessed among 37 *arboreum* gnotypes (including 2 checks) developed under different agro ecological situations of the country out of introgression with wild sources of *Gossypium* for biotic and abiotic stresses and fibre quality. The genotypes were grouped into nine clusters based on Mahalanobis D^2 statistic using Tocher's method. Maximum number of genotypes were grouped in cluster I (14), followed by cluster II (10) and cluster III (7). Cluster IV, V, VI, VII, VIII and IX had one genotype each. Maximum cluster distance of 53.13 was observed between cluster III and VIII, followed by cluster III and cluster IX (52.99), cluster I and cluster III (50.71), and cluster III and cluster IV (50.67). Number of bolls/plant contributed a maximum of 31.08 per cent to the total divergence, followed by

micronaire (19.37%) and boll weight (16.97%). The study indicated that geographical diversity need not always be associated with the genetic diversity.

1.36
Yield component analysis in diploid cotton (*Gossypium herbaceum* L.)

J. S. V. SAMBAMURTHY, S. RATNA KUMARI, N. CHAMUNDESWARI AND K. V. S. REDDY
Acharya N. G. Ranga Agricultural Unviersity, Regional Agricultural Research Station, Lam, Guntur-522 034

Variability, correation and path analysis were studied at Regional Agricultural Research station, Lam, Guntur during 2002-03 among five *herbaceum* collections made from different cotton growing areas of Gujarat, Karnataka and Tamil Nadu and from varieties released across the country for different physiological, agronomical and fibre quality traits. Significant genotypic differences were observed for all the sixteen characters studied. High GCV and PCV values were recorded for number of bolls/plant and seed cotton yield/plant. High heritability values coupled with high genetic advance were recorded for number of bolls/plant, specific leaf area and seed cotton yield/plant. The character association studies revealed that significiant positive association existed between seed cotton yield/plant and number of bolls/plant, and 2.5% span length and micronaire value, while significant negative association was there with days to 50 per cent flowering, plant height and boll weight. Path coefficient analysis revealed that number of bolls/plant had highest direct positive effect on seed cotton yield, followed by micronaire and bundle strength. So these traits were important yield components and direct selection may be made for these traits for improvement of *herbaceum* cottons.

1.37
Genetic variation for architectural and floral traits in cotton

SUMAN BALA SINGH, P. SINGH, JYOTI HEBBAR, SHINE JONES AND NITIN ZADE
Central Institute for Cotton Research, Nagpur-440 010

The genetic variability is important for any improvement programme in crop plants. The importance of architectural and floral traits further increases where the cost of hybrid seed has to be reduced through the use of male sterility. The floral traits and plant type help to attract honey bees. Variation in these traits affects visit of honey bees, thereby affecting pollination. Study on these parameters was carried out for two consecutive years on 29 CMS and B lines. Considerable amout of variation was found to exist for some architectural and floral tratis. Few characters were found to be very specific for the genotypes and could be used for DUS testing. The genotypes could be grouped into nine different groups on the basis of similarities.

Correlation studies showed that there was high and positive association between internodal length of sympodia and plant height, internodal length of main branch and plant height. Plant height also recorded positive association with floral traits *viz.* bract length, length of anther sheath and boll volume. Bract length showed high and positive association with number of other characters *viz.* bract width, petal length, style length, length of anther sheath, internodal length of sympodia. Positive association was also observed between petal length and petal width, petal length and length of anther sheath. All the above characters were directly or indirectly responsible for attracting honey bees. Khandwa 2, Laxmi, LRA 5166, Supriya, DHY 286 and SRT1 were some of the promising lines which possessed desirable floral traits. These lines could further be utilized in hybrid development programme.

1.38
Evaluation of inter-specific cotton hybrids under irrigated conditions

J. M. NIDAGUNDI AND MAHABALESHWAR HEGDE
Agricultural Research Station, University of Agricultural Scienses, Siruguppa-583 121

To identify the best performing intra-specific cotton hybrids of both public and private sector, a field study was undertaken at Agricultural Research Station, Siruguppa during the year 2002. Sixteen inter-specific hybrids were collected from the market and compared using RBD design and three replications. The characters *viz* boll number, boll weight, seed index, lint index, ginning out turn, seed cotton yield and lint yield were analysed. Kashinath retained maximum bolls/plant (38) and was *on par* with No. 6188, RCHB 21, DHB-105, Paras Lakshmi and significantly superior to all the other hybrids. However, boll weight was high in DCH-32 9 (4.62 g/boll) and there was no significant difference among the hybrids with respect to this parameter. Maximum seed index was recorded in Kashinath (11.08g) and was *on par* with DCH-32, Hyb. 6288, RCHB-21, DHB-105 and significantly superior to rest of the hybrids. The lint index varied among the hybrids with lowest (5.0) in Varalakshmi and highest (7.43) in DHB-105. The maximum ginning out turn of 42.37 per cent was recorded in Arati and was *on par* with DCH-32, DHB-290, RCHB-21, DHB-105 and significantly superior to rest of the hybrids. The highest seed cotton yield of 1002 kg/ha was recorded in Paras Lakshmi. The lint index was also significantly high (365 kg/ha) in Paras Lakshmi which was *on par* with DHB-105, DHB-290 and significantly superior to rest of the hybrids.

1.39
Evaluation of *intra-hirsutum* cotton hybrids under irrigated condition

J. M. NIDAGUNDI AND MAHABALESHWAR HEGDE
Agricultural Research Station, University of Agricultural Scienses, Siruguppa-583121

A field trial was laid out at Agricultural Research Station, Siruguppa, Karnataka under irrigated condition to evaluate 38 *intra-hirsutum* hybrids. The design followed was RBD with three replications. The parameters adopted for evaluations were boll number, boll weight, seed index, lint index, ginning out turn, seed cotton yield and lint yield. The maximum boll count (47.5/plant) was observed in JKSH 99, which was *on par* with Amarateja (42.2), Jyothi VCH 220 (38.9) and significantly superior to rest of the hybrids. Significantly high boll weight of 5.48 g/boll was recorded in Daftari which was *on par* with Amarkiran (5.09 g/boll), Brahma (4.9/boll) and significantly superior to rest of the hybrids. Seed index was high in JKSH 99 and was *on par* with Sanju, RCH-2, Selvam-6, Kranthi 215, Nandi-12, 29 Daftari, Shri Krishna 306 and significantly superior to rest of the hybrids. Lint index of 5.67 (minimum) and 7.77 (maximum) was observed in NHH-44 and Shri Krishna 306, respectively. GK111 recorded significantly highest ginning out turn of 45.07, followed by DHH 11 (44.61), Sasya 316 (44.27) and Amarkiran (43.87). Highest seed cotton yield was recorded in JKSH 99 (1712 kg/ha), which was *on par* with Amarateja (1650 kg/ha), Vishwanath (1604 kg/ha), NHH-44 (1364 kg/ha), Shri Krishna 306 (1377 kg/ha) and significantly superior to rest of the hybrids. Amarteja recorded highest lint yield of 729 kg/ha, which was significantly superior to rest of the hybrids. A few other hybrids which recorded comparatively higher lint yield in descending order were Shri Krishna 306, Vishwanath, JKSH 99 and Bunny.

BIOTECHNOLOGY

2.1
Evaluation of *Bt*–cotton and its scope in Punjab

R. K. GUMBER AND G. S. CHAHAL
Punjab Agricultural University, Cotton Research Station, Abohar-152 116

Now a days cotton cultivation has became a costly affair due to pest menace. Indiscriminate application of pesticides has resulted the development of resistance in bollworms to insecticides. Under such a situation, *Bt*-cotton has shown some promise. In the present study following *Bt* cotton hybrids were evaluated along with standard cultivars during kharif 2002 : Mech 915 non-*Bt*, Mech 162 Bt, Mech 162 non-*Bt*, Omshanker (check). LHH (check), and F 1861 (local variety). Each hybrids/variety was accommodated in a six rows plot of 6 m long. the rows were kept apart at 67.5 cm, while plant to plant spacing were maintained at 60 cm for hybrids and 45 cm for variety. Two pesticides, namely Confidor and Metasystox were applied for the control of sucking pests. For the control of bollworms (American bollworm and spotted bollworms), only two sprays (Thiodan and Quinalphos) were given to Mech 915 *Bt* and Mech 162 *Bt* whereas seven sprays were given to all other hybrids/variety. The incidence of cotton leaf curl virus (CLCuV) was very high on Mech 915 *Bt* (94.45) and Mech 915 Non-*Bt* (82.1%). The local variety F 1861 had low incidence of CLCuV (42.1%). Since the disease CLCuV appeared just after 25 days of sowing in Mech 915 *Bt*, it affected its performance drastically. The seed cotton yield of Mech 915 *Bt* was the lowest (1069.6 kg/ha) and it did not differ significantly from Mech 915 non-*Bt* (1102.1 kg/ha). The hybrid Mech 162 non-*Bt* had significantly higher seed cotton yield (1908.8 kg/ha) than Mech 162 *Bt* (1571 kg/ha) Mech 915 Bt and Mech 915 non-*Bt*. Highest seed cotton yield (2810.7 kg/ha) was obtained in check hybrid LHH 144. With regards to other traits, the ginning out turn of Mech 915 *Bt* and 162 *Bt* was higher than their respective non-*Bt* versions. lint index was highest (4.79) in Mech 162 non-*Bt*. The number of monopods and sympods were considerable high in Mech 162 *Bt* than Mech 915 *Bt*. Due to very high incidence of CLCuV, the plant height and number of bolls per plant were the lowest in Mech 915 *Bt*. The number of bolls per plant varied between 18.1 in Mech 915 *Bt* to 44.3 in check hybrid Omshanker. The Mech 915 *Bt* took less number of days to first flower and first boll bursting. It is apparent from the results that the high incidence of CLCuV in Mech 915 *Bt* and Mech 162 *Bt* was the major factor responsible for their low seed cotton yield. On the contrary the incidence of bollworms was cery low in the two *Bt* hybrids. It clearly shows the effectiveness of *Bt* gene in controlling the damage to cotton due to bollworms.

2.2
Agrobacterium mediated transformation and regeneration in *Gossypium arboreum* L. cotton (cv. PA-255)

B. N. CHINCHANE, S. B. NANDESHWAR, L. A. DESHPANDE AND V. N.CHICHANE
Department of Biotechnology, Marathwada Agricultural University, Parbhani-431 402

Transformation of diploid cotton (*Gossypium arboreum*) cultivar PA 255 (Parbhani Turab) was carried out using *Agrobacterium tumefaciens* strain LBA 4404 harbouring binary vactor containing npt-II gene and cry 1A (c) gene. A rapid and simple *in vitro* multiple shoot induction protocol was developed from cotyledonary node explants of cotton. The cotyledonary node explant consisted of lower 0.5 mm portion of hypocotyl and cotyledonary node without any cotyledons attached. Shoot tip explant from *in vitro* raised seedling of diploid cotton cultivar PA 255 were used to produce multiple shoots on a medium containing various concentrations of growth regulators like 6-benzylaminopurine (BAP) and kinetin. Among the combinations used, MS medium comtaining BAP (2 mg/lit.) and kinetin (1 mg/lit.) concentration was found to be the best for induction of multiple shoots. Shoot buds were allowed to grow into well-defined shoots. The elongated shoots were separated and rooted in modified MS medium supplemented with NAA. The putatively transformed shoots were tested for gene experession by ELISA. It was observed that some of the shoots were ELISA positive. This protocol is considered to be more suitable for micro-propagation, germplasm and genetic transformation experiments.

2.3
Performance and constraints in *Bt* (MECH hybrids) cotton cultivation at farmers fields

P. RAMASUNDARAM, R. K. INGLE AND H. L. GAJBHIYE
Central Institute for Cotton Research, Nagpur-440 010

The development of *Bt* cotton represents a technological change in cotton production. This technological breakthrough has the potential to expand the production frontier of cotton and improve producers welfare. Surveys of farmers growing MECH 184 and 162 *Bt* cotton were conducted during the cropping seasons 2002-03 and 2003-04 in Nagpur and Wardha districts. The average yield was 11.73 q/ha against the conventional hybrid of 9.72 q/ha. Both seasons witnessed low pest infestation levels. Per hectare gross and net returns were high in *Bt* (Rs. 24375 and Rs. 11783) over the conventional (Rs. 19722 and Rs. 9260) hybrid. While the seed cost of *Bt* was Rs. 4476 per ha compared to Rs. 1545 per ha for conventional hybrids, cost of plant protection dropped down to about half (Rs. 1097/ha) against conventional hybrids (Rs. 2195). The reduction in plant protection cost was attributed to the reduced number of sprays particularly against American bollworm in *Bt* cotton. The major constraints with respect to *Bt* cotton as reported or identified were-high price of seed, absebce of refugia (used in-lieu for gap filling), practice of strip cropping with redgram, small boll size, comparable susceptibility to sucking pest as in the concentional hybrids, incidence of wilt, weak extension and poor monitoring by the promoters.

2.4
Anatomical basis of resistance in cotton for sucking pest complex from *Gossypium arboreum* to *G. hirsutum via* haploid

S. S. MEHETRE AND V. R. PATIL
All India Co-ordinated Cotton Improvement Project, Mahatma Phule Krishi Vidhyapeeth, Rahuri-413 722

Cotton crop suffers in respect of growth, production and quality due to biotic stresses imposed by jassid (*Amrasca biguttula biguttula*), aphid (*Aphis gossypii*), thrips (*Thrips tabaci*) and whitefly (*Bemisia tabaci*). Specific leaf anatomical structure control resistance or susceptibility to various sucking pests. Hence, to breed genotype resistant to sucking pests with modification in cellular structure of leaf at genic level is required.

Asiatic cotton species (dipolid) have relatively longer distance of phloem from lower epidermis, compact cell arrangement of parenchyma tissue and longer palisade tissue while wild species have genetic resistance against the pest with very compact palisade tissues. So attempts have been made successfully to improve the *G. arboreum* lines with genic resistance of wild species through introgression breeding approach. Hybrids crosses between *G. arboreum x G. hirsutum* are difficult to obtain. Successful hybrid between haploid of *G. hirsutum x G. arboreum* var. G 27 is reported in the present study.

2.5
Embryo rescue for introgression of glandless trait

A. R. AHER AND G. C. SHINDE
All India Co-ordinated Cotton Improvement Project, Mahatma Phule Krishi Vidhyapeeth, Rahuri-413 722

The objective of this work was to develop *Gossypium hirsutum* [2n=4x=52 2 (AD)h] having a reduced level of gossypol in the seeds for food and feed and a high level of gossypol in the remaining organs to limit pest incidence. There are four Australian species known to have delayed morphogenesis pigmented gland trait i.e. whole plant having gossypol glands, except seed. The species are *G. sturtianum* (C1) *G. australe* (C3) *G. nelsonii* (G1) and *G. bickii* (G3) and all are diploid. Using these species as a donor and *G. arboreum* (2n=2x=26, 2A1) and *G. raimondii* (2n=2x=26, $2D_5$) as bridging species.

The *G. hirsutum-G. raimondii*-Australian species were tried by embryo rescue technique. The *Bt* media with various combination of ingredients gave good response as compared to various combination of MS media. The

hybrid between *G. arboreum x G. nelsonii* was sterile and further studies on doubling of chromosome was in progress.

2.6
Transformation of diploid cotton *Gossypium arboreum* through *Agrobacterium* mediated gene transfer

S. B. NANDESHWAR AND SANDHYA MOGHE
Central Institute for Cotton Research, Nagpur-440 010

In India, diploid cotton *Gossypium arboreum* and *G. herbaceum* presently occupy 20% of the total area. These are now receiving due attention by the farmers owing to its high yield potential, tolerance to sucking and other pests besides driught tolerance. Till date, several varieties of Bt-transgenic cotton have been developed and are under cultivation in different parts of the world. *G. arboreum* has remained deprived of such manipulations mainly due to short fibre length. The present studies were aimed to induce multiple shoots directly from shoot tips and were allowed to infect by *Agrobacterium* containing Cry IA © gene.

Shoot tip explant of *G. arboreum* cvs AKH 4, AKA 5 and RG 8 excised from *in vitro* germinated 7 days old seedling were cultured in Murashige and Skoog (1962) medium supplemented with various combination of 6-benzylamino purine and kinetin. In BAP and Kin combination proliferation of shoot buds leading to the differentitation of multiple shoots was observed. The proliferated mass of shoot bud was periodically subcultured and divided into small blocks for further growth and differentitation of shoots. The number of shoots per explant was in the range of 8-12 shoots. The elongated shoots with 3-4 internodes were separated and rooted in modified MS medium containing 0.1 mg/l IAA and 10 mg/l Thiamine but reduced concentration of glucose (15 gm/l). the medium was also supplimented with kanamycin (50 mg/l) and carbenicillin (500 mg/l). The rooted plants were successfully hardened and established in the soil. The leaf sample of putative transformed plants was tested for gene expression. Out of 98 sample tested, 13 were found positive.

2.7
Identification of cotton varieties through SDS PAGE

U. S. MISHRA, RAJEEV SHRIVASTAVA, J. K. SHARMA AND N. BISEN
Jawaharlal Nehru Krishi Vishwa Vidhyala, Regional Agricultural Research Centre, Khandwa-450 001

Characterization and evaluation of genetic variability has been one of the most intriguing problems of the biologists. The conventional methods of characterizing the genetic variability mostly involve various morphometric traits of the plants, which are often the ultimate results of a complex series of bio-chemical reactions and are mostly influenced by the environmental factors. But the electrophoretic pattern specific to cultivars are little affected by environment.

Total seed storage protein of the cotton varieties were separated and compared by sodium dodecyl sulphate polyacrilamide gel electrophoresis. The seed protein profile was a conservative and species specific trait. A total of twelve bands were obtained in 9 SDS-PAGE electrophorogrames. It was recorded that 5 bands (Rm value 1=0.2352, 2=0.2942, 4=0.3882, 8=0.5294 and 10=0.5882) were common in all the varieties. These bands could serve as a source of reference for inter gel or inter laboratory comparisons. It was interesting to note that band 5 (0.4117) was unique and present only in variety KH 11. Besides this, band 3 (0.3529) was present only in three varieties i.e. Sarvottam, Jawahar Tapti and KWA 7 (all *arboreum*). This band could be used in discriminating the *arboreum* varieties from *hirsutum* ones. Band 7 (0.4941) was present in JK 4 and Vikram. Band 9 (0.5632) was present in k2 and Vikram whereas band 11 was present in JK 4, K2 and JKHy 1. These bands could be used in discriminating the above varieties from each other. Similarly band 6 (0.4705) was absent only in K2 and might also be used as an effective criterion for discriminating the varieties.

2.8
Evaluation of *Bt* cotton hybrids for their resistance to diseases

R. P. LAKHTARIA
Gujarat Agricultural University, Cotton Research Station, Junagarh-362 001

Cotton is a very important cash crop of Gujarat. *Bt* and non-*Bt* cotton varieties were tested for their resistance to different diseases under protected and un-protected condition in the field. MECH 12, MECH 162, MECH 184, NHH 44 and G. Cot.Hy 10 were tested. All the *Bt* and non-*Bt* cotton hybrids as well as both the checks indicated resistant reaction against alternaria leaf spot. Grey mildew and bacterial blight were not observed in any variety under test. There was also no much difference in per cent disease intensity among the varieties both under protected and un protected conditions. All the *Bt* cotton hybrids recorded numerically higher yield of seed cotton than their respective counterparts (i.e. non-*Bt*).

2.9
Farmer's friendly scouting technique for the released *Bt* cotton hybrids

S. MOHAN, M. SUGANTHY* AND S. PALANISWAMY
Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore- 641 003

Field experiment was conducted at the farmer's field at Mettukadai, Erode district of Tamil Nadu during September 2003 where *Bt* cotton hybrids, namely, MECH 162 and MECH 184 were grown. Observation on the bollworm damage were recorded from randomly tagged plants with respect to the total number of bolls and number of infested bolls in : (i) the top one-third (t_1), (ii) top two-third (t_2) and (iii) the whole plant (t_3), from 40 days after sowing (DAS) onwards at weekly interval till 110 DAS. The data were subjected to statistical analysis using the mathemactical model called Allometric Model. The results revealed that if scouting on boll damage was taken between 45 and 60 DAS on top one-third of the plant (t_1) and top two-third of the plant (t_2), the equation *viz.,* $t_3 = 1.2761\ t_1^{0.7492}$ and $t_3 = 1.1413$ t20.8731, could be used to determine the boll damage of the whole plant, respectively. After 60 days, scouting could be carried out only at top 2/3rd portion of the plant. If it was taken up between 60 and 75 DAS, the equation *viz.,* $t_3 = 1.2100\ t_2^{0.8990}$, fitted the best to find out the relative boll damage of the whole plant. The allometric relationship of the relative boll damage between top two-third and the whole plant, during 75 to 90 DAS fitted very well with the equation, $t_3 = 1.3160t_2^{0.8964}$. Hence, there was no need to scout the whole plant for bollworm damage especially in *Bt* cotton.

2.10
Plant regeneration and shoot tip proliferation in different cultivars of cotton (*Gossypium hirsutum* L.)

PANKAJ BHATIA, SEEMA BHUTANI, SURENDER VERMA, RAJINDER KUMAR JAIN, VIJAY KUMAR CHOWDHURY
Department of Biotechnology, CCS Haryana Agricultural University, Hisar-125 004

For an efficient transformation procedure, regeneration from various cells/tissues is prerequisite. Experiments were conducted to optimize the conditions for plant regeneration and shoot tip proliferation in four varieties H777, H1098, HS-6 and RS875 and three hybrids HHH81, LHH144, Ankur 651 of cotton (*Gossypium hirsutum* L.) Embryogenic calli were initiated from hypocotyls and cotyledons on MS - based callus induction media containing glucose or maltose as carbon source and an auxin (2, 4-D or NAA) and/or a cytokinin (kinetin, zeatin or TDZ). The callus induction frequency varied between 32.3 and 85.4 percent depending upon the genotypes, explant type and medium used. Plants were regenerated from 5-6 weeks old calli on MSRI (MS-basal medium containing 0.1 mg/1 zeatin, 1.5% sucrose, 1.5% maltose, 0.2% charcoal) and MSR2 (MS-basal medium containing 5 mg/1 2iP, 0.1 mg/1 NAA, 3% maltose) media albeit with lower frequencies varying between 0 and 3.7 per cent. Genotypes HS-6 showed maximum shoots regeneration frequency (3.7%),

followed by H 777 (3.4%), HHH 81 (2.2%), LHH 144 (2.0%) and H 1098 (1.9%). No shoots were recovered in genotypes RS-875 and Ankur 651. For shoot tip proliferation, shoot tips of different genotypes were cultured on various media containing different concentrations of auxin (NAA), cytokinin (kinetin, BAP) and gibberellin (GA_3). Highest frequency of shoot tip proliferation was obtained in genotypes H777 (77.6%) and in other genotypes per cent shoot proliferation varied between 39.3 and 65.0.

2.11
Effect of growth regulators on calli induced from ovules of *Gossypium hirsutum* (tetraploid) x *Gossypium arboreum* (diploid) crosses

PANKAJ BHATIA, SURENDER VERMA, SEEMA BHUTANI, RAJINDER KUMAR JAIN, VIJAY KUMAR CHOWDHURY

Department of Biotechnology, CCS Haryana Agricultural University, Hisar-125 004

In the present investigation, the immature hybrid embryos of four crosses *viz.,* H777 x HD107, H777 x HD123, HS-6 x HD123 exicsed after three days of pollination were cultured on MS media containing various combinations and concentrations of indole acetic acid (IAA), kinetin (Kin) and casein hydrolysate (CH). Normally in many cases, expecially between tetraploids and diploids, the hybrid embryos abort at a very early stage. The early abortion of the embryo was prevented by treatment of the flowers immediately after pollination with a solution of gibberellic acid (50 mg/1) and naphthalene acetic acid (100 mg/1) and when grown to a stage where the embryo is few celled, the ovules were excised and cultured on media to form calli. The percentage of calli formation ranged from 12.4 to 88.2 per cent. The maximum response was observed in the cross H777 x HD107 (average 70.9%) when MS medium was supplemented with IAA (1.0 mg/1), Kin (0.2 mg/1), CH (250 mg/1) and sucrose (3%). Such a hybrid callus may provide means for obtaining genetic exchange in the interspecific hybrids. Hybrid callus can also be utilized to generate environments for enhancing chromosomal breakage and reunion events.

2.12
Effect of genotype and explant type on transient Gus expression in cotton (*Gossypium hirsutum* L.)

PANKAJ BHATIA, SEEMA BHUTANI, SURENDER VERMA, RAJINDER KUMAR JAIN, VIJAY KUMAR CHOWDHURY

Department of Biotechnology, CCS Haryana Agricultural University, Hisar-125 004

Efforts were made for *Agrobacterium*- mediated genetic transformation in genotypes H777, H1098 and HS-6. Hypocotyls, cotyledons, shoot tip pieces and calli of these genotypes were co-cultivated with *Agrobacterium* strain LBA-4404 harboring plasmid TOK233. Plasmid TOK233 has Gus as a reporter gene for studing Gus expression and efficiency of transformation. After three days of co-cultivation the calli and explants were analysed histochemically for transient Gus expression by immersing in Gus assay solution (consisting of sodium phosphate buffer and x-gluc as substrates) in multiwell plates and incubated at 37°C for 24 hours. The effect of explant type and genotype on transient Gus expression was studied. Maximum frequency of Gus expression was obtained in HS-6 (30%), followed by H777 (25%) and H1098 (18.1%). When callus tissues were used as explants transient Gus expression frequency was found highest (30%), followed by cotyledon explants (18.5%), shoot tip explants (16.6%) and hypocotyl explants (12.5%).

2.13
Evaluation of transgenic *Bt* cotton hybrids

S. V. KRISHNAMOORTHY AND S. SUBRAMANIAN
Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore-641 002

Development of transgenic cotton palnts is a preferred biotechnological approach to combat bollworm complex in cotton. Damage by spotted bollworm (*Earias vittella*), pink bollworm (*Pectinophora gossypiella*), *Spodoptera litura* and American bollworm (*Helicoverpa armigera*) is economically important. The performance of transgenic *Bt* cotton hybrids *viz.,* MECH 12 *Bt,* MECH 162 *Bt,* MECH 184 *Bt,* were evaluated along with their non-*Bt* counterparts and check varieties *viz.* Savitha and NHH 44 at Cotton Research Station, TNAU, Srivilliputtur. The trial was laid in CRBD with plot size of 27 m^2 replicated four times. An isolation distance of 50 m was maintained from other experimental plots. Bollworm pest load *viz.,* number and species of bollworm complex, larvae/five plants, damage to squares and bolls, locule damage etc. were recorded. Also, incidence of sucking pests, natural enemy population, yield and quality parameters were recorded. Among the *Bt* hybrids MECH 162 *Bt* recorded minimum leafhopper population at 44, 60 and 77 DAS. *Bt* hybrids *viz.,* MECH 12 *Bt* 162 *Bt* and 184 *Bt* were found to be more susceptible to stemweevil than their respective non-*Bt* counterparts. *Earias* damage was found to be minimum in *Bt* hybrids. *Bt* hybrids *viz.,* MECH 12 *Bt,* MECH 162 *Bt,* MECH 184 *Bt* recorded lesser *Helicoverpa* incidence to the tune of 75%, 80% and 66.7% respectively over non-*Bt* counterparts and checks. Fruiting body damage, boll damage and locule damage were found to be minimum in all the three *Bt* hybrids when compared to respective non-*Bt* hybrids and checks. Lesser incidence and slow build up of bollworms in *Bt* hybrids helped in reducing three rounds of spraying. MECH 162 *Bt* recorded maximum yield of 954.7 kg/ha. *Bt* hybrids recorded increased yield over non-*Bt* hybrids and checks.

2.14
Study on stomatal behaviour of transgenic *Bt* cotton (*Gossypium hirsutum*) hybrids

N.K. PERUMAL AND K. B. HEBBAR
Central Institute for Cotton Research, Nagpur- 440 010

A field experiment was conducted during 2002-03 season to study the stomatal behaviour and biomass production of *Bt* cotton hybrids. Three *Bt* hybrids (MECH 12, MECH 162 and MECH 184) and their non-*Bt* counterparts were grown along with hybrid NHH 44 (check). The stomatal resistance and transpiration rates were measured in 110-day-old plants at 11 and 14h. During the same period samples was collected and stem, leaf and fruiting part weights were recorded. In general, *Bt* hybrids had lower stomatal resistance and higher transpiration rate as compared to non-*Bt* hybrids both in the morning (except MECH 12 *Bt*) as well in the afternoon. The stem and leaf weight of *Bt* plants at this stage marginally decreased while the boll weight significantly increased in comparison with the non-*Bt* plants suggesting that the larger sink capacity had facilitated a better stomatal regulation in *Bt* plants.

2.15
Induction of tetraploidy in *desi* cotton (*Gossypium arboreum*)

K. P. SINGH, USHA, P. K. SAREEN AND ASHWANI KUMAR
Department of Genetics, CCS Haryana Agricultural University, Hisar-125 004

Creation of genetic variability plays crucial role in the development of varieties/hybrids combining yield and quality parameters. Of the various methods, induced mutations are a potential source of creating genetic variability in crop plants. *Desi* cotton varieties grown in north zone have poor spinming quality but have desirable characters like inherent resistance to cotton leaf curl virus (CLCuV) disease and also to sucking

pests. Therefore, efforts were made to get mutants in *desi* cotton with better fibre characteristics and suitable spinability through mutation.

Tetraploidy was induced in *desi* cotton cv. HD-107 using colchicine treatment of seed and seedlings. The treatment of seeds with 0.4 per cent aqueous solution of colchicine for 16 hours, followed by seedling treatment with 0.5 per cent aqueous solutionof colchicine for five days was most effective in inducing tetraploidy. The cytological studies revealed that the chromosome number in cv. HD-107 was 2n=26 whereas in the colchicine treated plant cv. HD-107 it was 2n=52. This confirmed the induction of tetraploidy in *desi* cotton cv. HD-107.

Chromosome pairing behaviour was recorded in terms of chromosome formula which represents the bivalent formation at metaphase-I in the cell. Diploid plants showed 13 IIs, while tetraploid plant exhibited usual 26 IIs., however, there was no formation of univalents (I), trivalents (III) or quadrivalents (IV) in the cells of tetraploids. This showed that the tetraploid plant was meiotically stable and was capable of producing fertile gametes as also confirmed by the pollen fertility test. The anaphase-I and anaphase-II cells exhibited equal distribution of chromosomes to the two/four poles. In diploid cells, 13 chromosomes lied at each pole whereas in tetraploid 26 chromosomes were held at each pole without any abnormality. This might have been possible because of formation of 26 II with no multivalents at Metaphase-I. Increase in cell diameter and stomatal size was observed in the induced tetraploid *desi* cotton plant. Pollen grains were fertile in case of both induced tetraploid and diploid *desi* cotton plant.

2.16
Influence of explant and enzyme source on isolation and viability of cotton protoplast from cotton *cv.* Sumangala

A. H. PRAKASH, N. GOPALAKRISHNAN AND T. P. RAJENDRAN
Central Institute for Cotton Research, Regional Station, Coimbatore-641 003

Development of protoplast system has increased the versatility of plants for being used in both physiological and genetic research. They have become indispensable tool in genetic engineering and crop breeding. The success of protoplast culture system primarily lies with consistent yield of a large number of uniform and highly viable protoplasts. The explants, enzyme source and techniques used for isolation of protoplasts have a bearing on the viability and subsequent growth. The protoplasts to be effectively utilized in biotechnological research have to be first standardized for repeated large scale isolation of protoplasts and effective culture methods. Without regeneration strategies, the improvement made through transformation is not discernible. In order to develop a viable protocol, hypocotyl and cotyledonary explants of cotton *cv.* Sumangala were exposed to three different sources of cellulolytic enzymes *viz.,* cellulase and macerozyme (from Ykult Biochem, Japan)-Onozuka enzymes; Celluloclast and Pectinex (Nova, Denmark); Cellulase and Pectinase (Genetix, USA), at varying levels of osmoticum and the digestion efficiency was studied. Mannitol at 9 per cent was found optimum for maintaining the spherical shape of the protoplasts. The enzyme combination of cellulase (2%), macerozyme (0.25%) from Onozuka was found effective in release of good viable protoplasts by 12-14 hours digestion period. The yield from hypocotyl explant was very low (2×10^3 protoplasts/g tissue) and released protoplasts were very fragile and could not sustain the purification process. Cotyledonary explants yielded healthy protoplasts (2×10^6 protoplasts /g tissues). MS basal medium with phytohormone combination of NAA (0.5 mgL^{-1}) + Kin (0.5 mgL^{-1}) and 2, 4-D (1.5 mgL^{-1}) + Kin (0.5 mgL^{-1}) and plating density of 2×10^4 protoplasts/ml led to first cell division after three days in culture. The divided cells continued to survive for 15-20 days. The plating efficiency was 10-15 per cent. Work is under progress for obtaining sustained cell division and regeneration of plantlets.

2.17
Response of *Bt* cotton to organics

J. A. HOSMATH, D. P. BIRADAR, S. K. DESHPANDE, S. V. DODAMANI AND M. D. RIZWAN HARIS
University of Agricultural Sciences, College of Agriculture, Bijapur-586 101

The experiment on *Bt* cotton (MECH-162) under rainfed condition was executed on the medium black soil of College of Agriculture, Bijapur during 2002-03 in split plot design replicated thrice. The annual rainfall received was 588.2 mm with 22 rainy days during the crop growth period (August-November). The initial available nitrogen was analyzed before and after the harvest of crop. Recommend dose of 30:15:15 kg NPK/ha (RDF) was appliled through farm yard manure (FYM), vermicompost (VC) and sunhemp germ manure (GM). Sunhemp was incorporated *in situ*. Cotton yield (kg/ha) was significantly higher in *Bt* (1172.39) than DHH-11 (875.96) and non-*Bt* (719-31). Among different sources of nutrients, significantly higher cotton yield (kg/ha) was obtained in RDF+FYM (1169.33) and FYM (1168.82) compared to RDF (937.85), VC (854.42), RDF+VC (829.42), RDF+GM (785.49) and GM (712.55). Similar trend was observed with respect to cotton yield/plant (g) boll weight/plant (g), number of bolls/plant, total dry matter production/plant (g), leaf area index and number of sympodial and monopdial branches. However, plant height (cm) significantly increased in DHH-11 (84.27) compared to *Bt* (78.74) and was *on par* with non-*Bt* (80.64). Plant height (cm) significantly increased in FYM (87.00), RDF-FYM (86.00), VC (82.66), RDF+VC (81.83) compared to RDF+GM (78.17), RDF (78.00) and GM (74.83).

2.18
Response of diploid and tetraploid genotypes of cotton for micropropagation

G. N. V. MALLIKARJUN, M. B. MISAL, A. W. MORE, M. V. DHUPPE
Marathwada Agricultural University, Parbhani-431 402

Cotton is cultivated mainly as a fibre crop in about 70 countries and hundreds of substances have been extracted from it and utilized for various purposes. So far, improvemnt in cotton crop was made only by utilizing conventional breeding methods like selection, hybridization, polyploidy, mutation, etc. Tissue culture techniques have shown ray of hope to overcome the species barriers and to develop cotton genotypes with characters transformed from wild species. Also, it can be helpful in commercial multiplication of varieties to maintain the genetic purity, for collection and storage of germplasm, and genetic transformation in replicant genotypes. Success of these techniques depends upon response of different genotypes to micropropagation at various levels of growth regulators for multiple shoot and root formation. The response of any growth hormone depends greatly upon the indigenous level of these growth regulators in the explants used for initiation of growth culture. Therefore, the present investigation was undertaken to study the response of different genotypes of cotton for micropropagation through shoot tip culture at different levels of growth regulators using cultivars PA-255 (diploid) and PH-348 (tetraploid). Shoot tips of both these cotton genotypes were inoculated on MS media supplemented with different concentrations of BAP (0.5, 1.0, 2.0 mg/l). Multiple shoot initiation was observed in both these varieties but genotypic differences were observed for various parameters studied for shoot initiation and proliferation. In PH-348, initiation of multiple shoots was observed in 24 days while PH-255 required 27.91 days. Likewise, number of shoots and shoot length (cm) were more in PH-348 than PA-255. Less number of days were required for root initiation in PH-348 (20) as compared to PA-255 (25) at different concentrations of NAA. This showed that the former line gave more positive response than the latter for micropropagation at the same concentration of growth regulator. As one genotype was diploid (PA-255) and other tetraploid (PH-348) in nature, there was wide genetic diversity. Due to these genetic differences their response to shoot initiation, number of multiple shoots and average number of shoots varied. This reveals that it is essential to have a separate protocol with optimum concentration of growth regulators for each genotype for substantial micropropagation.

2.19
PCR based detection, cloning and sequencing of Cp gene of CLCuV

SHEO RAJ, D. MONGA AND K. N. GUPTA
Central Institute for Cotton Research, Nagpur-440 010

Cotton leaf curl disease caused by whitefly (*Bemisia tabaci* Genn.) transmitted Gemini virus has emerged as a serious threat to the crop in north India. Timely detection and rouging of the infected cotton plants and the weed hosts is an effective cultural practice that can prevent spread of the disease to newer area. A quick and accurate diagnosis of disease is, therefore, extremely important for management. Molecular diagnosis of the diseases especially those caused by viruses are very important because it is difficult to detect them in the hosts or vectors by conventional methods. DNA was isolated from CLCuV infected and healthy cotton plants. The custom primer for Cp-gene (Gibco BRL) was designed. Amplification was performed in thermal cycler (M. J. Research). Amplified product was resolved in one per cent low melt agarose gel. The amplified fragment resolved around 1.2 kb band in CLCuV infected (HS-6) cotton plant DNA, but no fragment was observed in healthy (HS-6) cotton plant DNA. The amplified fragment (1.2 kb) was cloned in plasmid P drive 322 vector (Quiagen, TA cloning Kit). The fragment (1.2 kb) was sequenced by the Bangalore Geni Pvt. Ltd. Bangalore and was confirmed with the help of the available sequence (full length in 2.75 kb).

2.20
Anatomical studies in apomictic haploid genotypes of cotton evolved through interspecific hybridization

A. W. MORE, U. G. KULKARNI, A. S. ANSINGKAR, K. S. RATHOD
Marathwada Agricultural University, Cotton Research Station, Nanded-431 602

Cotton, the 'white gold', is a premier cash crop of the country with an enormous potential in sustaining employment generation and economic *cum* trade activity both internal and external. It is the king amongst agricultural crops taking into consideration the economic impact it generates. There is wide diversity for economical traits in all the four cultivated species of cotton. Most of the workers adapt interspecific hybridization for overall genetic improvement and to transfer the disease and pest resistance of cultivated or wild species into cultivated species. Interspecific hybridization may lead to the irregularities at meiosis, which may result into the aneuploidy, mixoploidy, haplidy, etc.

In an attempt to introgress sucking pest resistance trait of diploid cotton into tetraploid species, polyploidy was induced in *Gossypium arboreum.* The polyploid *G. arboreum* (2n=4x=52) was then pollinated on DCH-32 to obtain trispcies F_1 (*G. hirsutum x G. barbadense x 4n G. arboreum*). Trispecies F_1 was then used as pollinator and backcrossed with C_1 plant to get BC_1F_1 seeds. Two segregants, IS-244/4/1 and IS-181/7/1, with reduced morphological characters were isolated in BC_1F_2 and raised upto BC_1F_8 generation. These plants were suspected to be haploids by morphological character. Considering haploidy nature, it was expected for no boll setting. However, good boll setting evidenced, thereby supporting the presence of apomictic phenomenon. Anatomical study carried out in these lines to confirm the inheritance of anatomical parameters from *G. arboreum* for sucking pest resistance also supported their haploid nature. Reduction in plant height, leaf size, petal size, stamical column, number of anthers/flower, 100 seed weight and number of seeds/boll was observed in these lines as compared to *G. hirsutum and G. arboreum* checks. Anatomical parameters like total thickness of vein, width of phloem zone and width of xylem zone in IS-244/4/1 and IS-181/7/1 were 81.2 µ and 87.8 µ, 13.4 µ, respectively, which were smaller than the checks. Number of stomata/microscopic field in IS-244/4/1 and IS-181/71 were 15.25 and 18.35, respectively, while it was more in *G. hirsutum* (21.6) and *G. arboreum* (30.1).

Distance to phloem from lower epidermis and compactness of parenchymatus tissue from *G. arboreum* were successfully tailored in both the genotypes, which imparted them resistance against sucking pests. Anatomical parameters play a vital role in deciding resistance against sucking pest complex. Longer distance of first phloem sieve element from lower epidermis coupled with compact nature of parenchyma tissue of diploid

arboreum makes it difficult for sucking pest to penetrate style and suck the cell sap from phloem while in *hirsutum* it is shorter, which is in purview of the stylet, hence it is susceptible. Having resistance to sucking pest alongwith apomictic haploid nature, these lines can be used in further breeding programme for fixing heterosis as well as for evolving homozygous lines by inducing polyploidy in haploids.

2.21
Relative incidence of pest complex in MECH 162 *Bt,* MECH 162 non–*Bt* and Brahma cotton cultivars

B. RAJA, T. V. K. SINGH, K. VIJAYA LAKSHMI AND SREENIVASA RAO
Department of Entomology, Acharya N. G. Ranga Agricultural Universtiy, Rajendranagar500 030

An investigaiton was carried out to find out the relative incidence of pest complex in three cultivars *viz.,* in MECH 162 *Bt*, MECH 162 non-*Bt* and Brahma cotton cultivars. The treatment were replicated nine times in randomized block design. The population of leafhopper, aphid and whitefly was available invariably in all the three cultivars throughout the crop season, but cotton bollworm and spotted bollworm infestation was comparatively less in MECH 162 *Bt* cotton than other cultivars. Ther maximum incidence of *Heliccverpa armigera* was recorded during 14th and 15th week after sowing in the three cultivars.

2.22
Impact of biotechnology in cotton–an economic case study in Northern Telangana zone of Andhra Pradesh

R. VIJAYA KUMARI AND B. BHASKAR REDDY
Acharya N. G. Ranga Agricultural Univeristy, Regional Agricultural Research Station, Jagtial-505 327

Cotton cultivation in India has been plagued with rising cost of cultivation,ineffective pesticides, adultrated seeds and other inputs leading to consecutive crop failures and heavy indebtedness, ultimately resulting in suicides of some farmers. Biotechnology has enabled the Monsanto, a US seed company to develop *Bt* cotton mainly to reduce the pest attack and cost of cultivation. The Genetic Engineering Approval Committee (GEAC) of India permitted the Mahyco-Monsanto Biotech to commercially release three of the transgenic cotton varieties (MECH 12, MECH 162 and MECH 184) for sale, since the field trials carried out under the supervision of ICAR showed positive results. Consequently, MECH 162 was released for commercial cultivation in Andhra Pradesh in almost all major cotton growing districts. The present paper focuses on economic aspects of performance of *Bt* cotton in Northern Telangana Zone of Andhra Pradesh from ANGRAU. During 2002-03 there was high incidence of sucking pests, lower infestation of bollworms, higher investment, lower yields and lower net returns from MECH 162 (*Bt* cotton) than the non-*Bt* hybrids. Knowing the unsatisfactory performance of MECH 162, the company released other varieties, MECH 12, MECH 184 and from other companies RCH 2, RCH 20 in 2003. The results of the analysis of *Bt* cotton performance in the zone were found mixed varying with the district and also with the variety. MECH 12 performed well in many places with minimum number of spraying (3-5) and yields almost *on par* with other hybrids and ultimately fetching Rs. 10000-15000 higher net returns per hectare than the other hybrids during 2003-04. However, the prevalence of differential monsoon pattern and pest loads during the two seasons has not enabled to make a confirmation on the actual performance of *Bt* cotton. Hence, it is felt that minimum three to four years are needed to make an assertion on feasibility of adoption of *Bt* cotton. Further, indepth studies are needed on its aftermath effects on environment and ecosystem.

2.23
Performance of *Bt* cotton at farmers' fields

M. CHANDRA SEKHAR REDDY, K. V. SIVA REDDY AND A. NARISI REDDY
Acharya N. G. Ranga Agricultural University, Regional Agricultural Research Station, Lam, Guntur-522 034

Cotton in one of the most important commercial crops in Andhra Pradesh. The insect pest problems so far played a key role in deciding the success of cotton cultivation and was identified as a key factor influencing about 50 per cent of cost of cultivation. Andhra Pradesh was the first state in the country to have experienced the outbreak of whitefly during 1984-85 and 1985-86 and thereafter outbreak of *Helicoverpa armigera* during 1987-88 causing panic among the farmers, researchers and planners. At this juncture, the transgenic *Bt* cotton hybrids have come as an effective tool of IPM in managing *Helicoverpa armigera*. The *Bt* cotton hybrids MECH 12 and MECH 162 along with their non *Bt* counterparts and check NCS 145 (Bunny) were evaluated during 2002-03 at the farmers fields for pest incidence yield and economic benefits under Technology Mission on Cotton (TMC MMG 1 Project) functioning at Regional Agricultural Research Station, Lam. The incidence of sucking pests (jassid, thrips and aphid) was more whereas the incidence of *Helicoverpa* was less on *Bt* cotton as compared to non Bt and check (NCS 145). Bt cotton hybrids required less number of sprayings of insecticides as compared to non *Bt* and check (Bunny), which ultimately resulted in low cost of cultivation besides more yield and higher net returns.

The average cost of cultivation of MECH 12 *Bt* farms was estimated to be Rs. 21640/ha which was 17.88 per cent than the Bunny farmers. The expenditure on plant protection was 24.18 per cent less than the Bunny farmers. Cost of MECH 162 Bt cultivation was 19.61 per cent less than check and the cost of plant protection was also 28.27 less than check. The yield, gross returns and net returns of MECH 12 *Bt* were 5.11, 5.11 and 37.64 per cent more, respectively than check (Bunny). Though the yield and gross returns of MECH 162 *Bt* over check were 8.57 per cent less, but net returns were 12 per cent more due to less cost of cultivation when compared to check (Bunny). The MECH 12 *Bt* plots had higher cost benefit ratio of 1:1.96 due to less investment on plant protection as compared to the cost benefit ratio of 1:1.53 obtained by the non *Bt* farmers and 1:1.53 of check. The cost benefit ratio of MECH 162 was 1:1.74 as compared to 1:1.37 of non *Bt* and 1:1.53 by check.

2.24
Economics of *Bt* cotton cultivation in irrigated ecosystem

B. V. PATIL, M. BHEEMANNA, S. G. HANCHINAL AND N. KENGEGOWDA
University of Agricultural Science, Regional Agricultural Research Station and College of Agriculture, Raichur-584 101

Cotton bollworms, *Helicoverpa armigera* (Hubner), *Earias vittella* (F.) and *Pectinophora gossypiella* (Saunder) have made cotton cultivation uneconomical in recent years. Transgenic cotton hybrids with inbuilt d endotoxin were evaluated aganist these pests at Regional Agricultural Research Station (RARS) and at farmers' fields. MECH-162 *Bt* and non *Bt* during 2002-03 and MECH-184 *Bt* and non *Bt* during 2003-04 and local popular hybrids (NHH-44 and Bunny) were compared. Sprays were imposed as and when the pest population/damage crossed ETL. During 2002-03 a total of 3, 4 and 4 sprays were imposed on *Bt*, non-*Bt* and local hybrids, respectively at RARS. During 2003-04, 6, 12 and 12 sprays were inposed on *Bt*, non-*Bt* and local hybrids, respectively at farmers' field. Incidence of bollworms in *Bt* cotton MECH-162 and 184 was much below ETL. More number of opened bolls and less bad opened bolls per plant were recorded with significantly higher seed cotton yield in *Bt* cotton as compared to non-*Bt* and local hybrids. *Bt* cotton hybrids recorded 35 to 45 per cent increase in net profit over local hybrids making it commercially viable and profitable under irrigated ecosystem.

2.25
Studies on intercropping in *Bt* cotton hybrids

K. SANKARANARAYANAN, C. S. PRAHARAJ, P. NALAYINI AND B. DHARAJOTHI
Central Institute for Cotton Research, Regional Station, Coimbatore-641 003

The experiment was conducted with an aim to assess the status of raising intercrops under changed pest ecosystem by the influence of *Bt* techniques and also to test the suitability of intercrop for refugia purpose in the *Bt* cotton cultivation. The treatments including the intercropping of *Bt* cotton with red gram, cowpea, onion, *bhendi* and were compared in *Bt* cotton+20% non *Bt*, *Bt* cotton alone and conventional cotton (Bunny). The experimental results revealed that none of the treatments significantly influenced the plant height, number of sympodia per plant, number of bolls/plant, boll weight and seed cotton yield. Among the treatments tested in the experiment, *Bt* cotton and *bhendi* intercropping registered the maximum seed cotton yield (44.5 q/ha). The maximum gross return (Rs. 111295/ha), net teturn (Rs. 79129/ha) and benefit cost ratio (3.46) were observed with cotton+*bhendi* intercropping. Because of limited bollworm pressure the result did not reveal concrete information to test the suitability of intercrop for refugia purpose.

2.26
Morphological, cultural, pathogenic and molecular variation in *Ramularia areola* Atk., the causal organism of grey mildew disease of cotton

M. K. MESHRAM, D. L. WASULE, C. D. MAYEE AND SHEO RAJ
Central Institute for Cotton Research, Nagpur 440 010

Ramularia areola Atk., the causal organism of grey mildew disease of cotton, once a serious pathogen of diploid cottons (*Gossypium arboreum* and *G. herbaceum*) got adapted to tetraploid cottons (*G. hirsutum* and *G. barbadense*). Break down of the resistance of tetraploid cottons or shift in virulance of the pathogen could be responsible for the adaptation of the pathogen to tetraploid cottons. Morphological difference was observed in the size of conidiophores of *R. areola* from diploid cotton cultivar AKA-5 of *G. arboreum,* Jayadhar of *G. herbaceum* and tetraploid cultivar SRT-1 of *G. hirsutum.* Cultural characterstic *i.e.* growth rate and dry weight of mycelial mat showed variation in cultures of *R. areola* isolated from different cultivars. The isolates from the cultivars of *G. arboreum* and *G. herbaceum* were observed to be fast in growth as compared to the isolates from the cultivars of *G. hirsutum.* Twenty two cultivars/lines belonging to four cultivated species of cotton were tested for cross inoculation with eight isolates of *R. areola.* A distinct variability was observed among the isolates from the cultivars of *G. arboreum, G. herbaceum* and *G. hirsutum* for their ability to infect the plants of 22 cultivars/lines. Rapid and reliable protocl was designed for the extraction of genomic DNA from cultures of *R. areola.* RAPD-PCR profiles of the isolates from three cultivated species consistently generated polymorphic DNA pattern. Variation in morphological and cultural characters, host response to cross inoculation for development of typical areolate symptoms as well as molecular approach clearly gave an indication of the presence of different strains/races in *R. areola* having different pathogenic ability.

PRODUCTION TECHNOLOGY

3.1
Influence of wider spacing on seed cotton yield and its parameters in *Bt*-cotton

A. S. BRAR, R. K. GUMBER AND G. S. CHAHAL
Punjab Agricultural University, Cotton Research Station, Abohar-152 116

Plant population is a very important factor affecting cotton yield. The objective of the present investigation was to see weather wider spacing between rows had any effect on seed cotton yield and other parameters in *Bt*-cotton. The experimental materials comparised the following seven genotypes of cotton : Mech 915 *Bt*, Mech 915 non-*Bt*, Mech 162 *Bt*, Mech 162 non-*Bt*, Omshanker, LHH 144 and F 1861. The hybrids Omshanker and LHH 144 were included as check hybrids while F 1861 was included as local variety. These seven genotypes were grown on 5th May 2002 in a split plot design with three replications. Two spacings; S1 67.5 x 60 cm, and S2 : 100 x 60 cm were adjusted in the main plots whereas the genotypes were adjusted in sub plots. Row to row and plant to plant spacing for local variety F 1861 were 67.5 x 45 cm. The plot size was 6 rows of 6 m long for S1 spacing and 4 row of 6 m long for S2 spacing. The observations were recorded on dry matter content at 90 and 120 days after sowing (DAS), plant height at 90 and 120 DAS, number of bolls/plant and boll weight. The differnces among the genotypes were significant for all the traits. However, the differences due to spacing were significant only for plant stand at harvest and seed cotton yield. Likewise the interaction between treatment x spacing were non significant for all the traits except the dry matter content at 90 DAS. Though the dry matter content at 90 and 120 DAS did not differ at two spacings, both the *Bt*-cotton hybrids and check genotypes produced higher dry matter at wider spacing in comparison to narrow spacing. Contrarily, the plant height at 90 and 120 DAS in *Bt*-cotton hybrids was more at S1 spacing compared to that at S2 spacings. Amongst the *Bt*-cotton hybrids, the hybrid Mech 162 *Bt* had significantly higher yield (1246.7 kg/ha) and Mech 915 Bt (803.1 kg/ha) and Mech 915 non-*Bt* (508.9 kg/ha) at S1 spacing. The hybrid Mech 915 non-*Bt* was the only hybrid which gave high seed cotton yield (1025.6 kg/ha) at wider spacing between rows. Highest seed cotton yield (1899.2 kg/ha) was obtained for check hybrid LHH 144 and it was significantly higher then all other genotypes. The local variety F 1861 also gave significantly higher seed cotton yield 91729.8 kg/ha) than *Bt*-cotton hybrids; Mech 915 *Bt* and Mech 162 *Bt* had high number of bolls per plant at wider spacing. Like ordinary genotypes of cotton, the seed cotton yield of *Bt*-cotton hybrids Mech 915 and Mech 915 and Mech 162 reduced at wider spacing between rows. Similar results were obtained for check hybrids local variety. The effect of wider spacing on other traits like dry matter content, plant height, boll number and boll weight was non-significant.

3.2
Integrated nutrient management in enchancing and sustaining cotton (*Gossypium hirsutum* L.) productivity

K. SRINIVASULU, K. HEMA AND K. KRISHNA RAO
Acharya N. G. Ranga Agricultural University, Regional Agricultural Research Station, Lam, Guntur-522 034

A field experiment was conducted during the *kharif* seasons of 2002-03 and 2003-04 at Regional Agricultural Research Station, Lam, Guntur to study the effect of integrated nutrient management on productivity of cotton (*Gossypium hirsutum* L.) under rainfed conditions. The site of the experimental soil was vartisols with available N (low), P (low), K (high) and organic carbon 0.38%. Ten treatments comparised of application of FYM @ 10 t/ha^{-1}, 90-45-45 kg NPK ha^{-1} i.e. recommended dose of fertilizer (RDF), 90 kg N only, 90 and 45 kg N and P only, 100% RDF+FYM @ 5 t/ha^{-1}, 50% RDF+FYM @ 10 t/ha^{-1}, 50% RDF+FYM @ 5 t/ha^{-1}+2% DAP spray, 100% RDF+FYM @ 10 t/ha^{-1}+2% DAP spray, 50% RDF+sunhemp as *in situ* green manure and no fertilizer control were imposed on test variety Narasimha. Number of bolls per plant were significantly higher due to integration of FYM and 50% recommended dose of fertilizers than that of recommended dose of fertilizers alone. However, growth parameters i.e., plant height (cm), number of monopodial and sympodial branches per plant were not markedly varied due to the effect of fertilizer treatments. Application of FYM @ 10 t/ha^{-1} along with 50% RDF recorded deed cotton yield of 1856 kg/ha^{-1} which was on a par with that of 100% recommended dose of fertilizer (1829 kg/ha^{-1}).

3.3
Long term effect of manures and fertilizers on the productivity of rainfed cotton

K. VEERAIAH, N. SUBBA RAO, S. SRIDEVI, T. USHA RANI AND B. ROSAIAH
Acharya N. G. Ranga Agricultural University, Regional Agricultural Research Station, Lam, Guntur-522 034

A field experiment was initiated during the *kharif* 1991 on black cotton soils of Regional Agricultural Research Station, Lam, Guntur. The site of the experiment was clayey in texture. The soil was slightly alkaline in reaction (pH : 8.4) and non-saline in nature (0.6 dSm^{-1}), low in available nitrogen (196 kg/ha^{-1}) and phosphorus (22.5 kg/ha^{-1}), but high in available potassium (392 kg/ha^{-1}). Fertilizer recommendation for rainfed cotton is 90-45-45 kg/ha^{-1} (100% N-P-K). The treatments included 50, 100 and 150% NPK, 100% NP, 100% N alone, 100% NPK+FYM @ 10 t/ha^{-1} and control. A decade of experimentation has shown a significant increase in *kapas* yield with 100% NPK+FYM @ 10 t/ha^{-1} (1429 kg/ha^{-1}), followed by 150% NPK (1419 kg/ha^{-1}) over control (926 kg/ha^{-1}). Continuous addition of fertilizers both alone or in combination with manures has not shown any significant effect on the cotton quality parameters *viz.,* spun length, uniformity ratio, micronaire, maturity co-efficient and bundle strength. A significant decrease in soil pH (7.9) and EC (0.2 dSm^{-1}) was observed with the continuous addition of manures along with NPK fertilizer. An increase in the organic carbon content (0.8%) was also recorded due to continuous addition of FYM @ 10 t/ha^{-1} along with 100% recommended dose of NPK fertilizer. The available potassium content in soil was significantly increased (1290 kg/ha^{-1}) with the continuous use of manures compared to other treatments.

3.4
Fertilizer management for cotton based intercropping system under rainfed condition

G. K. KALYANKAR, A. N. GIRI, A. K. WADKUTE AND V. P. SURYAWANSHI
Department of Entomology Madhwara Agricultural Univeristy, Parbhani-431 402

A field experiment was conducted during the *kharif* 2000 on clay soil of MAU, Parbhani to find out the effect of fertilizer levels on yield and yield attributes of cotton under three different cropping systems *viz.,* sole cotton crop (90 x 60 cm^2), cotton intercropped with blackgram (1:1) cotton intercropped with soybean (1:1) and three fertilizer levels *viz.,* recommended fertilizer dose of N, P, K (RDF of cotton 100 : 50 : 50, blackgram 25 : 50 : 00, soybean 30 : 60 : 00 kg NPK/ha) for both crops on area basis (RDF), 75% RDF, 50% RDF for both crops on area basis. Two additional treatments of sole crop of blackgram with RDF and sole crop of soybean with RDF were also included. The experiment was laid out in FRBD. The seed cotton yield and yield attributes *viz.,* no. of picked bolls/plant and weight of seed cotton/plant were higher in sole cotton, followed by cotton+balckgram intercropping system. Every higher level of fertilizer recorded significantly higher seed cotton yield and yield attributes than its preceding levels. Highest cotton equivalent yield was obtained in cotton+blackgram, followed by cotton+soybean. In interaction of cropping system and fertilizer levels, cotton+blackgram with RDFB gave the highest cotton yield than other treatment combinations.

3.5
Influence of nitrogen and phosphorus levels on the yield of hybrid cotton in Tamil Nadu

P. JANAKI, A. RAJA RAJAN, A. VADIVEL AND R. SABRINATHAN
Tamil Nadu Agricultural University, Radioisotope (Tracer) Laboratory, Coimbatore-641 003

A pot culture experiment with cotton hybrid TCHB 213 was conducted using Aruppukottai soil. The soil was alkaline, calcareous, low in $KMnO_4$-N and Olsen-P and high in NH_4OAc-K. Each pot was filled with 25 kg of soil and two plants were maintained up to the last picking of *kapas*. The treatments included four levels of P as ^{32}P labeled SSP (@0, 30, 60 and 90 kg P_2O_5/ha^{-1}) and four levels of N (@ 0, 60, 120 and 180 kg N/ha^{-1} as urea).

The treatments were replicated thrice in a factorial CRD. Seed cotton yield was recorded from each pot and analysed for nutrients content. The results showed that the different levels of N and P tried in the experiment had significant effect on seed cotton yield. With the increase in the level of N applied, the seed cotton yield increased significantly from 16.20 g pot^{-1} in control (No) to 21.77 g pot^{-1} at 180 kg N ha^{-1} and was *on par* with the seed cotton yield at 120 (21.68 g pot^{-1}) and 60 (21.58 g pot^{-1}) kg N ha^{-1}. It suggested that 120 kg N ha^{-1} was sufficient for hybrid TCHB 213. It was found that the P applied @ 60 kg P_2O_5 ha^{-1} recorded significantly higher yield of seed cotton, and was *on par* with the seed cotton yields at 30 and 90 kg P_2O_5 ha^{-1}.

3.6
Effect of different levels of nitrogen and phosphorus on nitrogen use efficiency in hybrid cotton

P. JANAKI, A. RAJA RAJAN, A. VADIVEL AND R. SABRINATHAN
Tamil Nadu Agricultural University, Radioisotope (Tracer) Laboratory, Coimbatore-641 003

A pot culture experiment with cotton hybrid TCHB 213 was conducted using Aruppukottai soil. The soil was alkaline, calcareous, low in $KMnO_4$-N and Olsen-P and high in NH_4OAc-K. The treatments included four levels of P as ^{32}P labeled SSP (@0, 30, 60 and 90 kg P_2O_5/ha^{-1}) and four levels of N (@ 0, 60, 120 and 180 kg N/ha^{-1} as urea). The treatments were replicated thrice in a factorial CRD. The N use efficiency per cent by the cotton hybrid was worked out from the seed cotton yield, above ground biomass and their N uptake. A significantly higher N use efficiency was at the lowest level of N (N^{60}) and *vice versa*, indicating an inverse relationship between the N use efficiency and the level of N applied. The mean N use efficiency by the different plant parts of cotton was 25.12, 6.90 and 6.36 g per g of applied N in shoot, lint and seed respectively. Both the lint and seed utilized approximately the same per cent of N. The total N recorded in the above ground biomass was significantly high (20.91%) in 60 kg N ha^{-1}, followed by 120 and 160 kg N ha^{-1} with the values of 17.03 and 11.88 per cent, respectively. The N recovery per cent in lint and above ground biomass was influenced significantly by the application of fertilizer N. Of the total N (16.60%) recovered by the above ground portion, 8.76, 1/22 and 6.62 per cent was recovered by the shoot, lint and seed, respectively.

3.7
Response of cotton to farm yard manure in deep black cotton soils under rainfed conditions

S. RATNA KUMARI, P. SUBBARAVAMMA AND A. NARISI REDDY
Acharya N. G. Ranga Agricultural University, Regional Agricultural Research Station, Lam, Guntur-522 034

A field experiment conducted at Regional Agricultural Research Station, Lam, Guntur during 2002-03 crop season in deep black cotton soils under rainfed conditions to find out the effect of farm yard manure along with the recommended dose of fertilizers on yield and yield attributes of cotton in a split plot design with three replications keeping farm yard manure (FYM) as main treatment and different N, P and K combinations as sub treatments. Two entires, one variety (L 604) and one hybrid (NCS 145) were selected for this study. In both the entires, significant differences were recorded due to the application of FYM. The number of sympodia per plant, number of bolls per plant, boll weight, seed index, lint index and yield was significantly superior in the FYM applied plots as compared to non-FYM applied plots. In the variety L 604 T1 (recommended NPK : N 90, P 45, K 45 kg) recorded significantly superior yield. The treatments T3 (N 90, P 45, K 0) and T4 (N 90, P 0, K 45) also recorded significantly superior yield as compared to control (T1) in both the FYM and non-FYM appled plots. In the hybrid NCS 145, the yield was significantly high T1 (recommended levels of NPK : N 120, P 0, K 60) and T2 (N 0, K 60, P 60) as compared to control (N 0, P 0, K 0) in FYM and non-FYM applied plots.

3.8
Integrated nutrient management in cotton

K. MAHAVISHNAN AND MANGAL PRASAD
Division of Agronomy, Indian Agricultural Research Institute, New Delhi-110 012

Cotton (*Gossypium hirsutum* L.), the king of fibre crops and a crop of prosperity, is an industrial commodity of worldwide importance having a profound influence on man and matter. Despite having the largest area (25% of global cotton area), India ranks third among the world cotton producing centres, accounting for 12.3 per cent of global cotton production. Therefore, an investigation was carried out on sandy loam soils of Indian Agricultural Research Institute, New Delhi during *kharif* 2002 and 2003 to develop an integrated nutrient management package for sustainable production of cotton. The experiment consisted of eight treatments comprising of two levels of fertilizers *viz.* 50 and 100% (60 : 30 : 30 NP2O5 and K2O k/ha) alone and in conjuction with 12t of FYM and intercrop (green gram) along with control. The different treatments were 50% RDF, 100% RDF, FYM, intercrop, 50% RDF+FYM, 50% RDF+intercrop, 50% RDF+FYM+intercrop and control. The treatments were arranged in randomized block design and replicated thrice. Growth parameters *viz.,* plant height, leaf area index and dry matter production, yield attributing characters *viz.,* bolls per plant, boll weight and seed cotton yield were studies. The results showed that all growth parameters, yield attributing characters and seed cotton yield were higher with 50% RDF + FYM + inter crop (24.73 q/ha). The findings of the experiment revealed that the integrated nutrient supply generally had beneficial effect on soil fertility.

3.9
Productivity of cotton hybrids as influenced by varied levels of nutrients and spacings under irrigated conditions

M. A. BASAVANNEPPA, J. M. NIDAGUNDI AND D. P. BIRADAR
University of Agricultural Sciences, Agricultural Research Station, Siruguppa - 583 121

Intra-*hirsutum* hybrids are known for their wider adaptability, good quality parameters and have greater scope in irrigated conditions if cultivated with optimum agronomic management practices. In this context, a field experiment was conducted during *kharif* 2002-03 at Agricultural Research Station, Siruguppa, Karnataka to assess the performance of *intra-hirsutum* cotton hybrids to nutrient levels and spacings in vertisols under irrigated conditions. The experiment was laid out in a split-split plot design with three replications and it consisted of 24 treatment cobinations with four hybrids as main plots (*viz.,* V_1: RAHH-111, V_2: CNH-301, V_3: RAHH-92 and V_4: DHH-11) and two levels of nutrients *viz.,* F_1: 150:75:75 NPK kg/ha and F_2: 80:40:40 NPK kg/ha as sub plots and three levels of spacing (S_1: 90 x 30 cm, S_2: 90 x 60 cm and S_3: 120 x 30 cm) as sub-sub plots. The results revealed that among the hybrids, RAHH-92 registered significantly superior seed cotton yield (1600 kg/ha) compared to other genotypes. The increase in yield was to the extent of 24 and 27 percent over CNH-301 (1287 kg/ha) and RAHH-111 (1262 kg/ha), respectively. Further, application of 150:75:75 NPK kg/ha produced maximum seed cotton yield (1491 kg/ha) compared to application of 80:40:40 NPK kg/ha (1352 kg/ha) with an yield advantage of 10 per cent. Among the spacings, 90 x 30 cm recorded signifiantly maximum seed cotton yield of 1519 kg/ha as against other spacings of 90 x 60 cm and 120 x 30 cm and 120 x 30 cm with an yield advantage of 9 to 12 percent. Interaction effects between hybrids, nutrient levels and spacing indicated that DHH-11 performance was better at higher nutrient level (150:75:75 NPK kg/ha) with 90 x 30 cm spacing (1748 kg/ha) and was *on par* with RAHH-92 (1743 kg/ha).

3.10
Chemotactic behaviour of *Azotobacter* strains towards root exudates of cotton (*Gpssypium hirsutum*)

RAKESH KUMAR, RANJANA BHATIA AND NEERU NARULA
Department of Microbiology, CCS Haryana Agricultural University Hisar- 125 004

Biofertilizers play a vital role in sustainable agriculture by various mechanisms like N_2 fixation, P-solubilization, producing phytohormone and suppressing plant pathogens. The very first thing in stability and effectiveness of biofertilizer depends upon the establishment of bacterial strains in the rhizosphere of the plant. This interaction depends upon many factors and one of the important factors is plant exudates. Bacteria get attracted towards these exudates due to chemotaxis. The chemotactic behaviour of some chosen *Azotobacter* strains was studied against cotton seed exudates and these exudates were further analyzed for sugars, amino acid and other phytohormone substances. Seed of five varieties *viz.,* LD 327, F 846, LH 1556, HD 123 and H1028 was used for this study. Our studies revealed that variety also played an important role in chemotactic response. Bioinoculants like 103 ($9.6X10^3$), HT57 ($3.36X10^3$), AVK51 ($5.4X10^3$) showed maximum attraction in all the varieties used. These results indicated movement of inoculants towards characterstics roots exudates leading to better colonization of the bioinoculants strains in the cotton rhizophere, which caused greater plant growth.

3.11
Development of temperature tolerant microbial inoculants for cotton crop (*Gossypium hirsutum*)

RANJANA BHATIA, RAKESH KUMAR AND NEERU NARULA
Department of Microbiology CCS Haryana Agricultural University Hisar- 125 004

Cotton is one of the important commercial crops in India but its production and yield in the country is quite low as compared to the yield observed in leading cotton growing countries. Microbial inoculants constitute an important component of integrated nutrient management system that would lead to sustainable agriculture. Cotton is sown during April-May under irrigated conditions in states like Punjab and Haryana. In these months the temperatures rise very high often exceeding 45^0C. Bacteria thriving in tropical and subtropical soils may get eliminated at such high temperatures. Developing strains which could survive high temperatures could play a useful role as biofertilizers. Unlike chemical fertilizers they are non-polluting, ecofriendly and require low agricultural inputs. Fifteen high temperature tolerant (48^0C) cultures were isolated from soils of the cotton-wheat fields of Haryana, Punjab, Nagpur and Rajasthan. *In vitro* nitrogenase activity of these cultures was tested and some of them showed positive ARA results (47.5 to 510.0 nmoles ethylene hr^{-1} μg^{-1} protein) even at high temperatures. These cultures were also tested for their ability to excrete ammonia (3.78 to 6.37 $\mu g\ ml^{-1}$) and IAA (28.84 to 35.69 $\mu g\ ml^{-1}$). It was observed that there was formation of few new proteins at high temperatures which probably resulted into high temperature tolerance. Selected bio-inoculants are being tested on American cotton under pot and field conditions.

3.12
Evaluation of cotton genotypes for drought tolerance based on moisture indices

B. C. PATIL, T. S. ADARSHA AND S. R. KAREEKATTI
University of Agricultural Sciences, Agricultural Research Station, Dharwad-580 007

A field experiment was conducted during 2002-03 and 2003-04 at Agricultural Research Station, Dharwad, to study the stress indices, photosynthesis, yield and yield components of 20 different cotton genotypes. Mean performance of the genotypes showed that CPD-731 recorded the highest seed cotton yield (2614.9 kg), followed by L-762 (2400.9), GSHV-97/612 (2310.3) and CCH-526612 (2303.9) while Pusa-8-6 (1370.3),

VIKAS and RS-810 recorded lowest seed cotton yield. Under rainfed condtions SCS-37 (843.0) CPD-731 (791.7) and CPD-446 (776.8) recorded significantly more yield than pusa-8-6 (406.5), KH-134 (448.5) and TCH-1599 (499.5). The percent reduction in yield under rainfed condtion as compared to irrigated condition was minimum in RAH-30 (57.72%), followed by SCS-37 (58.85%) where as maximum reduction was observed in CCH-526612 (74.81%) and KH-134 (74.08%). Other genotypes ranged between these values. Highest plant height stress indices were recorded by SCS-37 (64.91), followed by L-762 (64.64), Vikas (64.36) and LH-1968 (64.34), while the lowest was recorded by CCS-526612 (49.91) and Pusa-8-6 (54.40). The highest rate of photosynthesis in irrigated condition was observed in L-762, followed by TCH-1599, RS-810 and CPD-731. Under rainfed condtion, the highest rate of photosynthesis was observed in L-762, followed by CPD-731 and the least in CCH-526612 and Vikas. Yield stability ratio was highest in RAH-30 (42.29), SCS-37 (41.15) and LH-1968 (39.59) while it was least in CCH-526612 (25.19), followed by KH-134 (25.92) and CA-29 (30.08). Drought susceptibility index (s) was highest in CCH-526612 (0.94), followed by KH-134 (0.93) and GBHV-139 (0.88), where as least drought susceptibility index (s) was recorded in RAH-30 (0.64), followed by Pusa-8-6 (0.66) and LH-1968 (0.74).

3.13
Response of hybrid cotton to graded levels of nitrogen and phosphorus under transitional tract of Karnataka

B. C. PATIL, T. S. ADARSHA AND S. R. KAREEKATTI
University of Agricultural Sciences, Agricultural Research Station, Dharwad-580 007

An experiment was conducted to know the response of hybrid cotton to graded levels of nitrogen and phosphours, at ARS, Dharwad under rainfed condtions. The initial soil N was low (190 kg/ha). The highest yield recorded was 1020 kg/ha with application of 90:45 kg NP/ha. RDF recorded 910 kg/ha. The green manuring of soybean did not give significantly higher over corresponding dose under sole crop. The increase in yield with 30:45 kg NP/kg was 3 to 4 fold more than at 60:45 kg NP/ha. The yield components (number of bolls per plant, boll weight, harvest index and number of fruiting points) followed the trend of yield. The maximum leaf area index recorded at 120 DAS was in treatment 120:45 kg NP/ha (1.46) followed by 90:45 Kg NP/ha (1.24) while, significantly less leaf area index was recorded by 0:0 and 30:30 kg 0NP/ha (0.57 and 0.82 respectively). With increase in N and P their was significantly increase in harvest index.

3.14
Effect of nitrogen application through drip irrigation on yield, nitrogen use efficiency and quality of hybrid cotton

R. VEERAPUTHIRAN, O. S. KANDASAMY, S. D. SUNDAR SINGH AND C. CHINNUSAMY
Department of Agronomy, Pandit Jawaharlal Nehru College of Agricultural & Research Institute, Karaikal-609 603

Field experiments were carried out at Tamil Nadu Agricultural University, Coimbatore during winter (August 1998-February 1999) and summer (March-August 1999) season to study the water use efficiency (WUE), nitrogen use efficiency (NUE), productivity and quality of hybrid cotton (TCHB 213) under two irrigation methods (drip and furrow) and at different levels and methods of nitrogen (N) application. The experiments were laid out in split plot design with three replications. The treatments consisted of three drip irrigation regimes (100, 75 and 50 per cent of furrow irrigation) in main plots and four levels of N application (drip fertigation at 120, 90 and 60 kg ha^{-1} and 120 kg ha^{-1} as drip band application) in subplots alongwith a control having furrow irrigation with band application of N at 120 kg ha^{-1} for comparison. The results revealed that drip irrigation and drip fertigation substantially increased the seed cotton to control. The seed cotton yield increased by mean drip irrigation over furrow irrigation and was 9.3 and 13.6 per cent during winter and summer seasons, respectively. Drip fertigation and drip band application of N increased the seed cotton yield by 10.8 and 9.7 per cent in winter and 15.0 and 10.9 per cent in summer season, respectively over furrow band application. By adopting drip fertigation, saving of irrigation water up to 43 per cent and nitrogen utilization by 50 per cent was achieved in hyrbid cotton in both the seasons of study. Drip irrigation and drip fertigation

substantially increased the WUE and NUE as compared to furrow irrigation with band application in both the seasons. Significantly better seed cotton quality parameters (ginning percentage, seed index, lint index and Bartlett's index, in both the seasons and staple length and micronnaire value (only in summer) were observed under drip irrigation as compared to furrow irrigation. Thus, in addition to higher seed cotton yield, substantial saving in irrigation water (up to 43%) and nitrogen (60 kg ha^{-1}), greater and consistent soil moisture availability with higher WUE and NUE indicated the feasibility of drip irrigation and fertigation for higher productivity and sustainable hybrid cotton production.

3.15
Effect of drip fertigation on yield, nutrient uptake and soil fertility status of hybrid cotton

R. VEERAPUTHIRAN, O. S. KANDASAMY, S. D. SUNDAR SINGH AND C. CHINNUSAMY
Department of Agronomy, Pandit Jawaharlal Nehru College of Agricultural & Research Institute, Karaikal-609 603

Field investigations were carried out at Tamil Nadu Agricultural University, Coimbatore during winter (August 1998-February 1999) and summer (March-August 1999) seasons to study the effect of drip irrigation and fertigation on yield, quality and nutrient uptake of hybrid cotton (TCHB 213). The results revealed that drip irrigation and fertigation significantly improved the seed cotton yield over furrow irrigation and band application of nitrogen in both the seasons. The increase in seed cotton yield by mean drip irrigation over furrow irrigation was 9.3 and 13.6 per cent during winter and summer season, respectively. Drip fertigation and drip band application of N increased the seed cotton yield by 10.8 and 9.7 per cent in winter and 15.0 and 10.9 per cent in summer season, respectively over furrow band application. Increasing the level of irrigation and nitrogen in drip irrigation increased the N, P and K uptake at different growth stages of hybrid cotton. Higher nutrient uptake was recorded with drip irrigation as compared to furrow irrigation in both the seasons. Among the nitrogen application methods,both drip fertigation and drip band application increased the nutrient uptake at almost all the stages of estimation than furrow band application. Significantly higher post harvest available N, P and K was associated with drip irrigation and fertigation as compared to furrow irrigation with band application of N in both the seasons of study. Thus, it was concluded that drip irrigation and fertigation was technically feasible for higher productivity, better quality of produce and improvement in nutrient uptake for sustainable hybrid cotton production.

3.16
Evaluation of nutrient levels for fruiting points, shedding percentage, yield and yield components under different moisture regimes in hybrid cotton

T. S. ADARSHA, B. C. PATIL AND S. R. KAREEKATTI
University of Agricultural Sciences, Agricultural Research Station, Dharwad - 580 007

A field experiment was conducted during 2001-02 and 2002-03 with eleven nutrient levels under different moisture regimes (rainfed and irrigated conditions). The number of fruiting points/plant indicates the potential ability of a plant to bear bolls. The hybrid DHH-11 is released for both rainfed and irrigated conditions; therefore, it was used in this experiment to evaluate the nutrient levels. Irrespective of moisture regimes, significantly higher number of fruiting points was observed in RDF (63.54), followed by 90:45 kg NP/ha (61.71) and 90:30 kg NP/ha (59.47) as compared to other nutrient levels. The treatment receiving no fertilizer recorded least number of fruiting points (38.74). Fruiting points differed significantly with respective to moisture regimes. Irrigated condition recorded more fruting points (60.96) as compared to rainfed condition (45.09). Interaction effect of nutrient and moisture regimes was non-significant. However, highest fruiting points were recorded in RDF with irrigation (73.80), followed by 90:45 kg NP/ha (69.28) and 90.30 kg NP/ha (68.22) with irrigation while lowest in 0-0 kg NP/ha (32.38) in rainfed condition. Highest shedding percentage was observed in treatment receiving no fertilizer under rainfed condition. RDF recorded the highest seed cotton yield (2193.7 kg/ha.) under irrigated condition compared to other nutrient levels. This was mainly

because of higher values of yield components such as highest number of bolls/plant (37.47), boll weight (5.52) and harvest index (38.45).

3.17
Effect of soil depths on biomass, yield and fibre traits of Mahyco *Bt* cotton rainfed hybrids

JAGVIR SINGH, M. R. K. RAO, P. SINGH, PUNIT MOHAN AND M. S. DESHMUKH
Central Institute for Cotton Research, Nagpur-440 010

In central and southern parts of India, transgenic *Bt* cotton hybrids developed by Mahyco-Monsanto were evaluated for different facets through multi location trials. Under agronomic evaluation, three *Bt* cotton hybrids MECH 182, MECH 162 and MECH 12 alongwith their non-*Bt* counterparts and one local check NHH 44 were grown in two different soils *viz.,* (<30 cm depth) and medium deep (30-90 cm depth) at Central Institute for Cotton research, Nagpur under rainfed conditons. Field experiment with seven hybrids was laid out in RBD with three replications. The soil characteristics of experimental sites were pH 8.2 and 8.3, EC 0.20 and 0.26 ds/m, OC 0.30 and 0.39%, clay 37 and 56% low in available N (110 and 150 kg/ha) and P (7.6 and 9.0 kg/ha) and high K (360 and 490 kg/ha) in shallow and medium deep soils, respectively. Crop was sown on 10th July in shallow and 16th July 2001, in medium deep. Gaucho treated seed was used for both *Bt* and non-*Bt* hybrids, except NHH 44. Two sprays of chemicals for controlling sucking pests were given to all hybrids. No spray for controlling bollworms was given to *Bt* hybrids while non-*Bt* hybrids were given one insecticidal spray.

All the *Bt* and non-*Bt* hybrids performed well in medium deep as compared to shallow soil with respect to growth weight of fruiting parts, yield and fibre traits. Biomass accumulation in *Bt* hybrids was significantly lower than non-*Bt* hybrids and NHH 44 at 120 DAS in both the soils. Similarly, weight of fruiting parts in *Bt* hybrids, specifically in MECH 184 and MECH 162, was higher leading to higher yields in both the soils. In general, *Bt* hybrids, except 12 *Bt*, significantly out yielded their non-*Bt* counterparts. MECH 184 *Bt* gave 51% higher yield in medium and 17% higher yield in shallow soil over NHH 44. Fibre values of all *Bt* and non-*Bt* hybrids were recorded numerically higher in medium deep as compared to shallow soil ar first picking. Staple length and bundle strength of fibre were slightly lower in *Bt* as compared to non-*Bt* hybrids under both the soil conditions.

It was thus clear from the investigations that *Bt* hybrids MECH 184 and MECH 162 were agronomically more efficient in terms of dry matter apportioning into the fruiting parts resulting in higher retention of early formed ones due to inbuilt resistance to *Helicoverpa armigera* and resulted in higher yields along with earliness, while in non-*Bt* hybrids early formed fruiting parts were lost due to bolloworms damage.

3.18
Optimization of soil and rainfall intensity for maximum yield potential of different varieties of cotton in M. P.

P. P. SHASTRY, PANKAJ SHAH, N. K. BISEN, D. S. TOMAR, R. S. SIKARWAR AND G. K. KOUTU
Jawaharlal Nehru Krishi Vishwa Vidhyalaya, Main Cotton Research Station, Khandwa-450 001

In Madhya Pradesh, cotton crop is being grown under low and high rainfall intensity with deep, medium and shallow types of soil situation. Constraints for each situation are different and package of practices evolved at any research station may rarely meet the need of varied cotton situations. Hence, the present study was undertaken to identify suitable cotton varieties for different agro-ecological situations for sustainable production under each situation with the ultimate aim to maximum the yield. Twelve varieties/hybrids (*arboreum* and *intra hirsutum* hybrids) were evaluated for yield parameters considering three soil types *viz.,* deep, medium and shallow soil in combination with two-rainfall intensity in a Randomized Block Design (RBD). In all the six situations *arboreum* genotypes were found to be superior. Best five entires irrespective of species were Sarvottam, hybrid KHH-110, Digvijay, Khandwa-2, G. Cot-16 and Jawahar Tapti.

3.19
Effect of irrigation and drip irrigation intervals in American cotton hybrid under micro and surface irrigation system.

M. S. BHATTOO, K. L. CHHABRA AND K. S. NIRANIA
CCS Haryana Agricultural University, Cotton Research Station, Sirsa-125 055

Cotton is one of the most important *kharif* crops of arid and semi-arid region of northern India. The study area falls in western part if Haryans state underlain by saline ground water, located in north-west India. Earlier studies have concluded that drip irrigation system resulted in higher yields and simultaneously saving of irrigation water. Therefore, keeping this in view a field study was undertaken during *kharif* seasons of 2000, 2001 and 2002 on loamy sand soil at Sirsa to evaluate the effect of irrigation regimes and irrigation interval through drip irrigation on seed cotton yield under micro and surface irrigation system. On the basis of pooled data the highest seed cotton yield was obtained in drip irrigation treatments where irrigation was applied at ETc=1 (potential evapotranspiration of the crop) as compared to water application equal to ETc=0.6, irrespective of dripper type and spacing. The seed cotton yield in borderstrip surface irrigation was considerably low to the extent of 45.5, 32.6 and 28.4 per cent as compared to drip, sprinkler and furrow method of irrigation, respectively. However, the irrigation interval in drip irrigation system had no significant effect on the seed cotton yield. The split application of irrigation with sprinkler system had no effect on seed cotton yield but it increased the EC of the surface soil with tube well water irrigation.

3.20
Growth and yield behaviour of different cotton genotypes as influenced by plant growth regulators

J. S. DEOL AND Z. S. BRAR
Department of Agronomy & Agrometeorology, Punjab Agricultural University, Ludhiana-141 004

Plant growth regulators (PGRs) have the potential to increase cotton yield through increased square and boll retention by keeping vegetative and reproductive growth in harmony. Effect of PGRs was studied during *kharif* seasons of 1998 and 1999 on two American cotton (*Gossypium hirsutum* L.) cultivars F 846 and LH 1556, an American cotton hybrid LHH 144 and a *desi* cotton (*G. arboreum* L.) cultivar LD 327. The sub plot comprised of of 6 PGR treatments *viz.,* control (water spray), foliar application of mepiquat chloride (MC) 200 ppm at 80 days after sowing (DAS), combined application of MC 200 ppm at 80 DAS and salicylic acid (SA) 20 ppm at flower initiation, SA 20 ppm at flower initiation, kinetin 20 at 25 per cent flowering and detopping done 60 DAS. *Desi* cotton cultivar LD 327 recorded the maximum plant height and sympodial branches/plant during both the years. The hybrid LHH 144 recorded highest leaf area index (LAI), total dry matter accumulation (TDMA), monopodial branches, flower and bolls/plant, setting percentage and boll weight during both the years. The hybrid LHH 144 recorded the maximum seed cotton yield of 12.6 and 18.6 q/ha, whereas, *desi* cultivar LD 327 recorded the minimum seed cotton yield of 10.0 and 13.7 q/ha during 1998 and 1999, respectively. F 846 and LH 1556 were statistically *on par* for seed cotton yield. LD 327 recorded maximum GOT (ginning out turn) and micronaire values, whereas, the hybrid LHH 144 recorded maximum seed index, lint index, 2.5% span fibre length and fibre bundle strength. Application of MC either alone or in combination with SA resulted in significant reduction in plant height, LA1 and TDMA over control. These two treatments improved the setting percentage and increased the sympodial branches and bolls/plant and seed cotton yield. PGRs failed to significantly influence the monopodial branches and flowers/plant, GOT, lint index, seed index and different fibre quality paramers.

3.21
Agronomic requirements of pre-released cultures trial

K. SANKARANARAYANAN, P. NALAYINI AND C. S. PRAHARAJ
Central Institute for Cotton Research, Regional Station, Coimbatore-641 003

The experiment was conducted to find out the spacing and fertilizer response of pre-released cultures. The treatment consisted of 3 genotypes (VARCH 87, RAHH 92 and RAHB 87) were sown at two different spacing (90 x 60 cm and 90 x 75 cm) and applied with two levels (100 and 125% of RD) of fertilizers (90 : 45 : 45 kg of N, P, K/ha, 112.5, 56.3, 56.3 kg N, P, K/ha). The experimental results revealed that genotypes had varied response to spacing and fertilizer levels. The entry RAHB 87 registered significantly higher plant height, number of bolls/plant, per plant yield and seed cotton yield. No significant difference was noticed in growth and yield characters between the two spacing tried. Significant difference was noticed between fertilizer levels. Application of 125 per cent of recommended level of fertilizer registered significantly higher number of sympodia/plant, number of bolls/plant, per plant yield and seed cotton yield. No significant interaction effect was found. It was concluded that recommended spacing (90 x 60 cm) is sufficient for all genotypes. The genotypes responded up to 125 per cent of recommended level of N, P and K/ha.

3.22
Effect of quality of irrigation water on the growth and yield of American cotton sown on various dates

G. S. BUTTAR, S. S. MATHUADA, R. K. MAHEY AND NAVNEET AGGARWAL
Punjab Agricultural University, Regional Station, Bathinda-151 001

An experiment was conducted at Punjab Agricultural University, Regional Station, Bathinda during the *kharif* season of 2003. Two dates of sowing (mid April and mid May) and four irrigation water quality treatments *viz.,* canal water through out the season (as per PAU schedule), tubewell water through out the season (as per PAU schedule), tubewell water as per the requirement of irrigation model (Pan-E based modified functional model used to compute soil water evaporation from the cropped soil) and alternate canal and tubewell water treatments were tested. The soil of the experimental site was loamy sand, low in available nitrogen and phosphorus and medium in available potash with pH of 8.4. Cotton c.v. LH-1556 was planted during middle of April and May 2003 and harvested on November 14, 2003. All the package of practices for fertilizers and pesticides were followed as per PAU recommendations. Seed cotton yield was reduced significantly due to delay in sowing which was 1196 kg/ha^{-1} in mid April and 910 kg/ha^{-1} in mid May sowing. Seed cotton yield was statistically *on par* with respect to the different irrigation water quality treatments. The highest seed cotton yield of 1189 kg/ha^{-1} was recorded in the treatment where canal water was applied through out the growing season, followed by 1091 kg/ha^{-1} in case of alternate canal and tubewell irrigation. However, seed cotton yield was the lowest (986 kg/ha^{-1}) in the treatment where tubewell water alone was applied throughout the growing season. The reduction in yield due to late sowing and tubewell irrigation was due to reduced number of bolls and boll opening percentage.

3.23
Effect of sowing dates, planting methods and irrigation scheduling on water relations, growth and yield of cotton

G. S. BUTTAR, S. S. MATHUADA, R. K. MAHEY, NAVNEET AGGARWAL AND RAMINDER KAUR

Punjab Agricultural University, Regional Station, Bathinda-151 001

An experiment was conducted at Punjab Agricultural University, Regional Station, Bathinda during the *kharif* seasons of 2002 and 2003 to find the effect of sowing dates, planting methods and irrigation scheduling on the water relations, growth and yield of cotton. Cotton cv. LH-1556 was sown on two different dates i.e. end March-mid April and mid-May in both the years by two methods i.e. flat and on ridges. Canal water irrigation was applied through out the season following two irrigation schedules i.e. irrigation as per PAU schedule and irrigation as per the requirement of the irrigation model (Pan-E based modified functional model). The soil of the experimental site was loamy sand, low in available nitrigen and phosphorus and medium in available potash with pH of 8.4. All the practices for fertilizers and pesticides were followed as per PAU recommendations. Mean of two years indicated that seed cotton yield was reduced significantly with delayed sowing to mid May as compared to early sowing in April. This may be due to the reduction in number of opened bolls/plant. Seed cotton yield was not effected by different irrigation schedules as model based irrigation gave seed cotton yield which was *on par* with irrigation as per PAU schedule. Cotton crop sown on the ridges resulted in 7-8 per cent higher seed cotton yield as compared to the flat method of sowing during both the years. There was water saving of 35 per cent in ridge sown crop as compared to flat sowing.

3.24
Effect of spacing and detopping on growth, yield and yield attributing characters of American cotton

P. L. NEHRA AND K. C. NEHARA
Agricultural Research Station, Sriganganagar-335 001

A field experiment was conducted at Agricultural Research Station, Sriganganagar (Rajasthan) during *kharif* 2000 to 2002 to find out the effect of spacing and detopping on growth, yield and yield attributing characters of American cotton. The soil of experimental field was sandy loam in texture, low in available nitrogen, medium in available phosphorus and high in available potassium. The experiment was laid out in split plot desing consisting of four levels of spacing (60 x 20, 60 x 30, 67.5 x 20 and 67.5 x 30 cm) in main plot and four stages of detopping *viz.,* no detopping, detopping at 25, 35 and 45 days after sowing in sub plot with four replications. The newly released variety RS-875 was the test crop. The crop was sown by dibbling method using 2-3 seeds/hill in the month of May during all the three years. Optimum plant population was maintained by gap filling and thinning at appropriate time. The crop was raised as per package of practices.

The pooled data revealed that spacing S_1 (60 x 20) cm gave significantly higher seed cotton yield (1924 kg/ha) over S_2 (60 x 30 cm) (1794 kg/ha) and S_4 (67.5 x 30 cm) (1605 kg/ha) and remained statistically *on par* with S_3 (67.5 x 20 cm) (1889 kg/ha). This might be due to significant increase in plant population under this treatment over wider spacing. However, number of bolls and boll weight were significnatly higher in the case of wider spacing but could not compensate the yield due to higher plant population under narrow spacing. Detopping at 35 days after sowing (D_2) significantly increased seed cotton yield (1900 kg/ha) over no detopping D_0 (1689 kg/ha) and 25 DAS D_1 (1700 kg/ha) and remained statistically *on par* with detopping at 45 DAS D_3 (1762 kg/ha).

3.25
Agronomic requirements for new hybrid Phule-388 under summer irrigated conditions

J. D. THOKALE, R. S. RAUT AND S. S. MEHETRE
All India Co-ordinated Cotton Improvement Project, Mahatma Phule Krisha Vidhyapeeth, Rahuri-413 722

With a view to assess agronomic requirements for a new hybrid, Phule-388, experiments were conducted during 2000-01 to 2003-04 at Cotton Improvement Project, MPKV, Rahuri. Split-split plot design was followed. The main plot treatments comprised of hybrids, with DCH-32 as check. The sub plot treatment comprised of three fertilizer levels and sub-plot comprised of three spacings. The experimental soil was medium deep black. From the three years pooled data it was concluded that phule-388 produced significantly higher seed cotton yield (20.53 q/ha) than that of DCH-32 when planted at a distance of 90 x 120 cm and fertilized with 120 kg N + 60 kg P_2O_5 + 60 kg k_20/ha. All the growth and yield contributing characters were significantly influenced in this treatment. Highest maximum gross monetary returns (Rs 51325/ha), net monetary return (Rs. 23760/ha) and benefit-cost ratio (1.86) were recorded in this treatment.

3.26
Pollination efficiency of *Apis* spp. in cotton (*Gossypium hirsutum* L.)

RACHNA GULATI, S. K. SHARMA AND B. S. CHHILLAR
Department of Entomology, CCS Haryana Agricultural University, Hisar-125 004

Cotton (*Gossypium hirsutum* L.) crop var HS 6 was grown in randomized block design following recomended agronomical practices. Studies revealed that during full bloom, ten insect visitors (Hymenoptera, Diptera) visited cotton flowers out of which *Apis* spp. were predominant ones. Amongst bees, *Apis dorsata* was the most abundant visitor (5.2 bees/m^2/5min.), followed by *A. florea* (3.93 bees/m^2/5 min). Foraging avtivity was maximum between 0700-0800 h, which declined significantly thereafter. Pollination efficiency of *A. dorsata* was greater in terms of foraging speed (5.8 sec/flower) and foraging rate (8.2 flowers/5 min.). *A. florea* was comparatively a slow worker on cotton flowers taking 13 sec/flower and visiting 4.8 flowers/min. Role of honeybees in fruit set was evaluated by caging 17 plants in fine mesh net cage and tagging the equal number of flowers in open pollianted plots. Open plots visited by honeybees (and other insects) showed more fruit set (66.11 bolls) and cotton weight (118.70g) as compared to 34.41 bolls and 82.64 g of cotton, respectively, in caged plots.

3.27
Isolation of pink pigmented faculative methlotrophic bacteria (PPFMB) from phyllosphere of cotton, its compatibility with bioinoculants/bioagents and scope for cotton nutrition

P. NALAYINI, R. ANANDHAM, P. CHIDAMBARAM AND T. P. RAJENDRAN
Central Institute for Cotton Research, Regional Station, Coimbatore-641 003

Pink pigmented facultative mehytobacterium (PPFMB) are ubiquitius in nature and are found in a variety of habitats including soil, dust, fresh water lake sediments, leaf surface and nodules which are capable of growing on single carbon compound. These bacteria influence seed germination and seedling growth by producing plant growth regulators like zeatin and related cytokinins. Hence, there is a possibility of increasing the efficiency of the conventional bio inoculants by co inoculating with PPFMB. An attempt was made to isolate PPFMB from the phyllosphere of cotton cv., LRA 5166 and this isolate along with other growth promoting rhizobacteria were used alone or in combination to study the vigour index of cotton cv., LRA 5166. The results revealed that cotton seeds soaked with *Azospirillum lipoferum* and PPFMB isolated from phyllosphere of

cotton cv LRA 5166 produced significantly higher vigour index. The compatibiltity of Methylobacterium with other plant growth promoting rhizobacteria, bioagents *viz., Azospirillum lipoferum* (AZ 204), *Bacillus megaterium* var *phosphaticum* (PSB 1), *Pseudomonas fluorescens* Pf1, *Bacillus subtilis* BS.N1 *Bacillus thuringiensis* kurstaki (HD-73) was confirmed by cross streaking each culture in glycerol peptone agar. Some of our isolates of *Methylobacterium* isolated from cotton *viz.,* Savita, RCH 144 Bt, RCH 144 non Bt, RCH 2 Bt, MCU 7, and Surabhi oxidized sulphur and these Metylobacterium isloates has potential to be used as sulfur oxidizers to enhance the sulfur oxidation. Since the sulfuric acid was the end product of S oxidation, the insoluble phosphorus was also made soluble under lab condition which was confirmed for a *Methylobacterium isolate from* Savita. The above pot culture and laboratory experiments indicate that *Methylobacterium* spp. may be useful for developing microbial consortium expusively for cotton for sulfur and, phosphorus nutrition besides its ability to produce growth promoting substances and N–fixation.

3.28
Effect of different dates of sowing, moisture regimes and genotypes on seed cotton yield

S. R. KAREEKATTI., B. C. PATIL AND T. S. ADARSHA
University of Agricultural Sciences, Agricultural Rsearch Station, Dharwad-580 007

An experiment was conducted at Agricultural Research Station, Dharwad during *kharif* 2003-04 to know the effect of different dates of sowing (D), moisture regimes (M) and genotypes (G) on seed cotton yield. Two genotypes LRA-5166 and DHH-11 were evaluated for irrigated and rainfed conditions at two dates of sowing.The data showed significant differences among dates of sowing, moisture regimes and genotypes and the interaction DxG and Dx MxG. The seed cotton yield was 1224.5 kg/ha in D_1 while it was only 733.0 kg/ha in D_2. The mean yield in irrigated conditions were 1567.0 kg/ha while it was only 390.4 kg/ha in rainfed condition. The hybrid DHH-11 recorded significantly more yield (1017.2 kg/ha) than LRA-5166 (938.4 kg/ha). The interaction of DxG and DxMxG were significant.

The number of bolls/plant in irrigated condition was 13.1, while in rainfed condition it was 8.6. The genotype DHH-11 recorded significant more number of bolls (12.51 bolls/plant) while LRA-5166 recorded less number of bolls/plant (10.8) and there was significant interaction of dates and genotypes. First date of sowing (D_1) recorded significantly more boll weight (3.04 g/boll) as compared to D_2 (2.79 g/boll). Irrigation recorded significantly more boll weight (3.12 g) as compared to rainfed (2.71 g). The genotype DHH-11 recorded significantly more boll weight (3.00 g) compared to LRA-5166 (2.76).

The data on leaf area index showed significant differences between dates, moisture regimes and genotypes at harvest. There was peak leaf area index at 135 DAS, which showed significant differences between dates, moisture regimes and genotypes. D_1 recorded 2.89 leaf area index compared to D_2 (2.10). Irrigated treatment recorded treatment recorded 2.98 while rainfed recorded 2.22 leaf area index. LRA-5166 recorded significantly more leaf area index 2.60 while DHH-11 recorded 2.39. Observation on total dry matter production was recorded from 30 days onwords at an interval of 15 days till harvest. D_1 recorded significantly more total dry matter as compared to D_2. The genotype DHH-11 recorded significantly high total dry matter as compared to LRA-5166. At harvest all the interaction effects were significant.

3.29
Approaches for developing abiotic stress tolerant genotypes of cotton

A. H. PRAKASH, N. GOPALAKRISHNAN AND S. E. S. A. KHADER
Central Institute for Cotton Research, Regional Station, Coimbatore-641 003

Major threat of abiotic stresses in realization of crop yields demands application of integrated conventional and biotechnological techniques such as expression of candidate genes, right promoters, transcription factors, marker-assisted selection, gene-fishing, somaclonal variation and biochemical pathway engineering. Achieving profitable yields of major crops like cotton under adverse abiotic stress situations necessitates probe into

physiological and biochemical mechanisms of adaptation. The complex biochemical and physiological processes acting in an integrated way have been studied in cotton genotypes/hybrids under waterlogging, salinity and drought stress. Accumulation of osmoprotectants, free radical detoxification, enzyme activation and desirable metabolic changes played key role in stress tolerance. Higher level of activities of enzymes *viz.,* nitrate reductase, glutamine synthetase, glutamate dehydrogenase and peroxidase (ranging 20-35%) in moderately drought tolerant genotypes point to their possible role in overcoming moisture stress, while the susceptible varieties could be characterized by the quantum rise in activities of hydrolytic enzymes like RNase, acid and alkaline phosphatases. The tolerant cotton genotypes exhibited higher photosynthetic rate, chlorophyll content and moderate transpiration rate, while susceptible genotypes revealed drastic reduction in these parameters under waterlogged conditions. Impaired nitrgoen assimilation enzyme system was apparent in cotton genotypes susceptible to waterlogging. The temporal distribution of peroxidase was markedly affected in susceptible genotypes (50-60%) as compared to 15-25 per cent in tolerant genotypes, explaining their reduced growth and development due to improper quenching of free radicals. The deleterious effect of chloride and sulphate anions on the growth and metabolism of cotton seedlings could partly be overcome by application of phytohormones such as Indole acetic acid, Cyclic AMP and GA_3 through their beneficial influence on restoring the activities of metabolically important enzymes.

The prospects of inserting desirable foreign genes have opened up new vistas for achieving the goal of developing newer plant types. The breeding programmes, both conventional and modern, including gene isolation, their characterization and biochemical markers, have started yielding dividends in introduction of favourable tolerance traits in cotton. Attempts have been made through wide hybridization techniques for useful introgression of genes from wild germplasm of cotton. Intensive efforts are further needed to custom-tailor biochemical mechanisms, stress responsive genes, DNA sequencing, gene regulation, protein targeting and suitable slection procedures for generation of cotton plants with superior quality and high yielding ability even under challenging and adverse situations.

3.30
Screening of cotton and wheat varieties under different planting systems for cotton-wheat system

B. D. SHARMA, SAJJAN KUMAR, P. K. TYAGI AND S. S. RATHEE
Wheat Section, Department of Planting Breeding, CCS Haryana Agricultural University, Hisar-125 004

Cotton-wheat is one of the crop sequences in India which is practised on about 1.6 million ha area in north India. Compared to rice-wheat, cotton-wheat has less water requirement, higher water use efficiency, higher benefit: cost ratio and complementary exploitation of soil rhizoshpere for nutrients. From late seventies, the area under cotton-wheat system is increasing in Haryana progressively. In this belt American cotton of medium staples is grown under assured irrigation and the crop matures by December leading to delayed sowing of wheat crop. In order to increase the prdocutivity of the system, there is a need to identify early maturing varieties of cotton and wheat having high production potential for system sustainability and suitable tillage practices for the system.

A field experiment was conducted at Research Area, Department of Plant Breeding during 2000-01 to 2002-03. The experiment was laid out in split-plot design with three replications. The soil of the field was loamy sand and low in nitrogen, medium in phosphorus, high in potassium and low in organic carbon. Five varieties of cotton (RS 875, H1098, LH 900, LH 1556 and RS 2013) and four varieties of wheat (PBW 373, PBW 343, UP 2425 and Raj 3765) under FIRB and Flat bed systems were evaluated for cotton-wheat sequence. The yields of seed cotton and wheat were *on par* under FIRB and Flat bed planting system. Cotton variety LH 1556 produced significantly higher seed cotton yield over other cotton varieties whereas wheat yields of PBW 343 and PBW 373 after cotton varieties H 1098 and RS 2013 were higher. On an average the wheat varieties PBW 343 and PBW 373 maintained superiority over other varieties. Thus, in Haryana, suitable varietal sequence is H1098 and LH 1556 of cotton and PBW343/PBW373 of wheat for Hisar region.

3.31
Identification of drought tolerant cotton genotypes based on some physiological parameters

S. S. BHATADE, M. H. CHAVAN AND S. S. MORE
Marathwada Agricultural University, Cotton Research Station, Nanded-431 601

Cotton is mostly grown as rainfed crop in Maharashtra state. The crop generally suffers from inadequate moisture during its various growth stages due to erratic monsoon. Under such a situation, it is essential to identify and grow cotton genotypes which are tolerant to drought for obtaining sustainable cotton yield. With this objective in view, 12 promising cotton genotypes from different species were screened for drought tolerance on the basis of yield and some physiological parameters under natural situations. Twelve cotton genotypes were grown in a replicated trial for three seasons *viz.,* 2001-02, 2002-03 and 2003-04 under rainfed condition at Parbhani. Recommended cultivation practices were followed for obtaining normal crop growth. The leaf samples were collected for estimation of relative water content and chlorophyll stability index during dry spell of 20-25 days in respective seasons.

On the basis of average of three years data it was found that *Gossypium arboreum* genotypes *viz.,* PA-402 and PA-405 were drought tolerant recording chlorophyll stability index below 20 per cent, relative water content above 80 per cent and higher seed cotton yield. Among *G. hirsutum* varieties/hybrids tested, NH-594, PH-348, NH-545, NHH-44 and PHH-316 were found to posses drought tolerance, recording less chlorophyll stability index and higher relative water content under moisture deficient/dry spell conditions. It is adocated to grow these cultivars for obtaining sustained yield under rainfed situation of Marathwada region.

3.32
Transplantaion–a technique of raising cotton crop under saline condition

C. L. GOSWAMI AND PROMILA KUMARI
Department of Botany & Plant Physiology, CCS Haryana Agricultural University, Hisar-125 004

Germinating cotton seeds and seedling were found to be very sensitive to salinity. Therefore, transplantation technique has been developed to harvest good crop under saline conditions, while using normal sowing methods, no crop stand was earlier established. The technique can also be used for gap filling under normal soil condtions and it can also be commercialised for hybrid cotton cultivation. Saplings of American (*Gossypium hirsutum* CV. H-1098, H-1117) and *desi* (*Gossypium arboreum* CV. HD-324) were raised using soil:sand FYM (3:1:1) potting mixture in 4”x9” polethylene bags. The saplings were hardened by giving one cycle of wet and dryingt or irrigated withsaline water before one week of transplantation. When the splings were 40-45 days old, these were transplanted either to pots having 0, 4, 8 and 12 Sdm^{-1} chloride dominated salinity (directed seeded plants were used as control) or to soil salinity patches (8.0-10.0 Sdm^{-1}) under field conditions. In these patches no crop stand was under obtained by using normal sowing.

These was mortality of saplings under screen house as well as under field conditions, bowever, young saplings showed mortality upon transplantation under both the conditions. Direct seeded plants were more sensitive due to more absorption of salts from the medium. In such plants dry matter production and its partitioning in various plants parts were more adversely affected with increasing levels of salin8ity. Carbon dioxidee exchange rate, stomatal conductance and transpiration also exhibited similar trends. Flowering peaks delayed and total number of flower reduced with high level of salinity. Lower level of salinity stimulated growth and development of crop and thus proved beneficial. Transplanted plants yielded better than direct seedes. Similarly under field conditions seed cotton yield was 25-40% less than normal crop stand. Even then it was better to have something than nothing. Harening of saplingts with drought prior to transplantation imparted more tolerance to plants as compared to saline hardening.

3.33
Integrated weed management in cotton

D. P. DHONDE, R. S. RAUT, S. S. MEHETRE, J. G. THOKALE
All India Co-ordinated Cotton Improvement Project, Mahatma Phule Krishi Vidhyapeeth, Rahuri-413 722

In the Deccan canal tract of western Maharashtra, cotton is mainly grown under irrigated conditions which encourages heavy weeds infestation. For obtaining good seed cotton yield, cotton crop needs to be kept weed free for 70 DAS. With this view experiments were conducted during the 2001-02 to 2003-04 at Cotton Improvement Project, MPKV, Rahuri. The experiment was laid out in RBD, which comprised of seven treatments with four replications. The experimental soil was medium deep black and the hybrid used was NHH-44. From the pooled data of three years it was concluded that the highest seed cotton yield (11.6 q/ha) was recorded by the treatment two hand weedings + two hoeings and it was *on par* with treatment Envoke 75 WG @ 10.0 g.a.i./ha (10.33 q/ha). Lowest weed biomass production (11.11 q/ha) and highest weed control efficiency (46.79%) was recorded from the treatment Envoke 75 WG @ 10.0 g.a.i./ha.

3.34
Studies on intercropping of pigeon pea on growth, yield and economics of rainfed cotton

H. L. HALEMANI, S. S. HALLIKERI, S. S. NOOLI AND R. A. NANDAGAVI
University, of Agricultural Sciences, Agricultural Research Station, Dharwad-580 007

A field experiment was laid in Randomized Block Design for three years from 1997 to 1999 to study the effect of intercropping of pigeon pea on cotton yield at Dharwad on medium deep black soil under rainfed conditions. There were eight treatment combinations of intercropping systems comprising of four row proportions (RP) (2:1, 3:1, 4:2 and 6:2) and two pigeon pea populations (PP) (50 and 75% of sole crop) and these were compared with sole crop of cotton and pigeon pea. The experiment was replicated thrice. Mean of three years data indicated that seed cotton yield in sole cotton cropping system was found significantly higher (1673 kg/ha) than the cotton yield obtained in intercropping systems. The next best cotton yields of 1030 and 1013 kg/ha were harvested from intercropping of cotton and pigeon pea with 6:2 RP at 100:50 and 100:75 PP, respectively. The economics analysis of the systems revealed highest monetary advantage in terms of net returns with sole cotton (Rs. 18, 960). The next best was Rs. 16,160 from intercropping system with 6:2 RP at 100:50% PP, followed by 4:2 row proportions at 100:50% PP. These systems gave more net returns than sole pigeon pea. As the cost of cultivation of sole cotton was less as compared to intercropping system, B : C ratio was slightly more with sole cotton (2.30) as compared intercropping systems. Among the intercropping systems 6:2 RP at 100:50% PP recorded higher B : C ratio of Rs. 2.00 as compared to the B : C ratio of 1.92 obtained with sole pigeon pea. Hence, it was concluded that sole cotton as well as intercropping of cotton and pigeon pea with 6:2 row proportions at 100:50 percent plant population were more profitable cropping systems than sole pigeon pea under rainfed condition.

3.35
Effect of irrigation scheduling through drip on cotton productivity

S. S. HALLIKERI, H. L. HALEMANI, R. A. NANDAGAVI AND S. S. NOOLI
University of Agricultural Sciences, Agricultural Research Station, Dharwad-580 007

In drip irrigation, technological innovations are to be exploited to achieve the twin objectives of higher productivity and better water use efficiency. With this background, a field experiment was laid out from 2001 to 2002 to find out the optimum scheduling of irrigation under drip irrigation to enhance the cotton productivity at Dharwad. There were five treatments *viz.,* irrigation scheduling at 0.6, 08 and 1.0 ETc for drip

irrigation under paired row planting compared with surface irrigations at paired row as well as normal planting alongwith four replication. Mean of two years data indicated that drip irrigation at 0.6 to 1.0 ETc produced *on par* yield levels, whereas surface irrigation at paired row planting or at normal planting with AAFI produced significantly lower yields over drip irrigation. Further, the higher yields of cotton in drip irrigation treatments were due to more number of bolls and *kapas* yield per plant as compared to surface methods. Surface irrigation with paired row planting was better than normal planting with AAFI. It was concluded that drip irrigation for cotton at 0.6 ETc with paired row planting was ideal to produce highest yield of cotton with least water requirement.

COTTON SEED & FIBRE TECHNOLOGY

4.1
Evaluation of undescript varieties of cotton for yield and fibre quality

R. K. GUMBER, G. S. CHAHAL AND P. K. VERMA
Punjab Agricultural University, Cotton Research Station, Abohar-152 116

More than 60 undescript varieties/hybrids of cotton are under cultivation in Punjab. In this study, samples of about 30 undescript varieties of cotton were collected from farmers field. Out of these, 16 undescript varieties, which cover a considerable area in Punjab, were evaluated at Cotton Research Station, Abohar along with standard checks F 1816 and LH 1556 in a randomized block design with three replications. Each variety was grown in 4 rows of 5.4 m length on May 4, 2002. The rows were kept apart at 67.5 cm while plant-to-plant distance was maintained at 45 cm. The observations were recorded on seed cotton yield, number of bolls/plant, boll weight, (g), seed index, ginning out turn (%), lint index and fibre quality parameters. None of the undescript varieties gave seed cotton yield higher or *on par* with the two check varieties F 1861 (2161 kg/ha) and LH 1556 (1357 kg/ha). Amongst undescript varieties, performance of P 36-1 (1221 kg/ha), Sikanderpuria (1209 kg/ha) and M 1352 (1205 kg/ha) was better than other varieties. Similar results were obtained for number of bolls/plant. The boll weight was highest (3.38 g) in undescript variety Anandgarh. The boll weight of check varieties F 1861 and LH 1556 was 3.03g and 2.43g, respectively. The seed index varied from 7.67 in LH 911 to 9.67 in undescript varieties Paras, Anandgarh and PK 54-2. The ginning out turn of most of the undescript varieties was higher than the check varieties F 1861 (31.2%) and LH 1556 (29.5%). The highest ginning out turn was observed in variety P 36-1 (36.5%) followed by Rajasikander (35.3%), Anandgarh (35%) and Udangsuper (34.9%). For lint index also, the undescript varieties had better lint index than standard varieties F 1861 (4.12) and LH 1556 (3.78). High lint index was reported in undescript varieties Anandgarh (5.21), P 36-1 5.13), Rajasikander (4.73) and Vishnu 1008 (4.70). With regards to fibre quality parameters, the undescript variety Local selection-1 from village Kundal had 2.5% span length of 28.8 mm, which was *on par* with the check variety LH 1556 (28.4 mm). The 2.5% span length in other undescript varieties varied between 23.6 mm in LH 911 to 26.6 mm in Paras. The undescript variety Udangsuper had a fine fibre with a micronaire value of 3.5. The chech variety F 1861 had a micronaire value of 5.2. The fibre strength was also highest (23.1 g/tex) in undescript variety Sikanderpuria as compared to 22.4 g/tex in check variety LH 1556 and 22.2 g/tex in F 1861.

4.2
Extent of heterosis in private sector hybrids of *Gossypium hirsutum* L.

R. K. GUMBER, G. S. CHAHAL AND P. K. VERMA
Punjau Agricultural University, Cotton Research Station, Abohar-152 116

More than 45 private seed companies are involves in cotton research and development and have been offering their hybrids for national/state trials for multilocation evaluation. The objective of the present study was to evaluate the performance of few selected hybrids of different private seed companies. Six private sector hybrids, namely, PKC 70, Sandacot Dhaval 2, RCH 134, RCH 101, Vijeta 77 and Nath Rani; and three public sector hybrids LHH 1128, LHH 1299 and LMSH 115 were evaluated in a randomized complete block design in three replications at Cotton Research Station, Abohar during *kharif* 2003. The hybrid LHH 144 and variety F 1861 were included as standard checks. Each hybrid was accommodated in 4 rows plot of 7.2 m long. The

rows were kept apart at 67.5 cm, while plant to plant distance was maintained at 75 cm for hybrids and 45 cm for variety. Five competitive plants were taken from each hybrid/variety to record observations on number of monopods and sympods, plant height (cm), number of bolls, boll weight (g), seed index, lint index and ginning out turn. In addition, data on seed cotton yield (kg/ha) and lint yield (kg/ha) were also recorded. The differences among the genotypes were significant for all the traits, except number of sympods/plant. Since the sowing was done very late (May 26, 2003), the *per se* performance for most of the traits was comparatively low. The hybrid PKC 70 had the lowest number of monopods (1.73), whereas LHH 1299 had the highest of monopods (5.20). The hybrid RCH 134 and LMSH 115 also had considerably high number of monopods (4.80). Plant height varied from 79.3 cm in hybrid PKC 70 to 130.6 cm in hybrid LMSH 115. The hybrid Vijeta 77 (31.3), RCH 134 (28.5) and Nath Rani (28.2) had significantly higher number of bolls/plant as compared to check hybrid LHH 144 (20.6). The check hybrids LHH 144 (4.12) and LHH 1128 (4.37) had higher boll weight. Rch 101 (2381.2 kg/ha) and RCH 134 (2300.8 kg/ha) gave significantly higher seed cotton yield than check hybrid LHH 144 (1830.4 kg/ha) and check variety F 1861 (1735.1 kg/ha). The lowest seed cotton yield was observed in hybrid Nath Rani (1173.2 kg/ha) and LMCH 115 (1054.7 kg/ha). Similar results were obtained for lint yield. The ginning out turn was highest in hybrid Sandacot Dhaval 2 (41.8%), followed by PKC 70 (37.2%), Nath Rani (36.3%), RCH 134 (35.9%) and RCH 101 (35.4%). RCH 134 (32.6%) and RCH 101 (37.2%) showed highest standard heterosis over check variety F 1861 for seed cotton yield. The hybrids Nath Rani and Sandacot Dhaval 2 expressed negative heterosis for yield. Likewise, the hybrids RCH 134 and RCH 101 had high heterosis for lint yield and boll number. Vijeta 77 expressed high heterosis (20.19) for number of bolls and LHH 1128 for boll weight (43.2%). The hybrid Sandacot Dhaval 2 had high heterosis for ginning out turn (14.6%) and lint index (17.7%). It is evident from the results that two private sector hybrids, *viz.,* RCH 101 and RCH 134 are very promising and needed multilocation testing.

4.3
Combining ability analysis and inheritance of fibre quality traits in American cotton (*Gossypium hirsutum* L.)

U. SIVA PRASAD, V. CHENGA REDDY AND A. NARISI REDDY
Acharya N. G. Ranga Agricultural University, Regional Agricultural Research Station,Lam, Guntur-522 034

A Line x Tester analysis involving 7 lines and 6 testers was conducted for yield and fibre quality traits *viz.,* ginning percentage, 2.5% span length (mm), micronaire (10-6 g/in), maturity coefficient, uniformity ratio, bundle strength (g/tex) and seed cotton yield per plant (g) during 2002-03 crop season at regional Agricultural Research Station, Lam to study the nature and magnitude of gene action. The combining ability analysis revealed that both additive and non-additive gene action was found to be predominant for ginning percentage, 2.5% span length, micronaire, maturity coefficient and seed cotton yield per plant. The non-additive gene action was important for uniformity ratio, while additive gene action predominant for bundle strength. The estimates of *gca* effects indicated that the lines NA 1325 and NDLH 1678 and tester Sumangala were found to be good general combiners for one or two fibre quality traits *viz.,* ginning percentage, 2.5% span length, micronaire, maturity coefficient uniformity ratio, bundle strength besides seed cotton yield. The crosses NDLH 1678 x Sumangala (high x high), L 756 x Simangala (high x high) and L756 x SRT 1 (high x low) recorded high *sca* effects and *per se* performance for ginning, 2.5% span length, uniformity ratio and bundle strength besides seed cotton yield.

4.4
Prospects of utilization of cotton stalk and its by-products

P. D. GAIKWAD AND S. C. PANDEY
Jawaharlal Nehru Krishi Vishwa Vidhalaya, All India Co-ordinated Cotton Improvement Project, College of Agricultural, Indore-452 001

The cotton plant stalk, normally an agricultural waste, is available to the extent of more than 15 million tones annually. Besides its limited use as fuel, its utilization in preparation of boards, filler pulp paper regenerated cellulose and cellulose derivaties (esters etc.) and microcrystalline cellulose in remarkable. The chemicals like lignin and furfural compounds are derived from cotton stalk. The two types of pulps i.e. soda pulp and Kraft pulp are prepared from cotton stalk. Its utility in new print and packaging industries is being highlighted. As a rich source of lignocelluloses waste materials, the pleurotus species of mushroom is now a days grown on the media prepared from cotton stalk material. The other industrial use of the cotton stalk is preparation of biogas. The recycling of this cotton waste can serve the four purposes : help in disposal of harmful waste from the field, additional employment to the rural population, supplementation in income of the farmer, and partly replacement of wood for furniture and building materials.

4.5
Genetics and order effects of mean halo length in triallel crosses of upland cotton (*Gossypium hirsutum*)

A. RAMALINGAM, P. AMALABALU AND N. SIVASAMY
Tamil Nadu Agricultural University, Cotton Research Station, Srivilliputtur-626 125

Sixty three-way crosses involving six parents were tested in a randomized block design. The mean data on mean halo length were analysed as per the triallel analysis model. Predominance of epistatic gene effects (additive x dominance) was observed for mean halo length. Hence, the improvement of this trait would, therefore, need delayed selection and intermating the segregants followed by recurrent selection. All the three-way crosses showed invariably order effect for mean halo length. The triplet in the order of (Sharadha x JR 36) x MCU 5 had significant three line specific effect with high *per se* performance. When this order was changed as (MCU 5 x Sharadha) x JR 36 and (MCU 5 x JR 36) x Sharadha, the t_{ijk} effect in these triplets was non significant and negative in direction. Hence, the order effect has to be decided well before attempting the multiple crosses. The parents *viz.,* MCU 5 and TCH 1002 were observed as good general combiners being grand parent as well as immediate parent in three way crossed for mean halo length.

4.6
Stability for fibre quality characters in *Gossypium hirsutum* L.

J. M. PATIL AND B. D. SOLUNKE
All India Co-ordinated Cotton Improvement Project, Mahatma Phule Krishi Vidhyapeeth, Rahuri-413 722

In cotton, fibre is the main product which is used mainly for manufacturing fabrics. There is a need to develop a variety having combined superiority for most of the fibre quality characters in a single genotype. Hence, in the present investigation efforts were made to know the nature of genotype x environment interaction for fibre quality parameters.

Ten *Gossypium hirustum* L. cotton genotypes alongwith two released varieties developed at Cotton Improvement Project, MPKV, Rahuri, were grown in R.B.D. with two replications for four consecutive years (1999 to 2002). All samples were ginned carefully in laboratory and lint samples were analyzed for fibre quality parameters by standard CIRCOT methods at CIRCOT, Mumbai.

Stability parameters were estimated as per the method suggested by Eberhart and Russel (1966). The pooled analysis of variance showed that there were highly significant differences among the fibre quality parameters. Variance due to years (linear and nonlinear), genotype and year (nonlinear) interactions were highly significant. G x Y linear effect was non significant when tested against pooled deviations for all the characters, except extensionability. Hence, only mean performance (x) and mean square deviation (S^2di) were cosidered to identify stable genotype for fibre quality characters.

When mean values and mean square deviation were studied for each genotype separately for different fibre quality traits the genotypes RHC-191, RHC-994, RHC-9795, RHC-1094 and JLH-168 could be considered as the most stable for 2.5% span length whereas the genotypes *viz*., RHC-1594, RHC-1694, RHC-994, RHC-1189 and LRA-5166 for uniformity ratio, the genotypes *viz*., RHC-9745, RHC-0688, RHC-1489 and JLH-168 for micronaire and the genotypes *viz.*, RHC-191, RHC-1594, RHC-9745 and JLH-168 for tenacity were found stable. The genotypes *viz.*, RHC-1594 and JLH-168 were found stable for four fibre quality traits and hence these genotypes could be used to incorporate the genes for stability in the desired cultivar through combination breeding.

4.7
Inheritance of lint colour and heterosis studies for yield and fibre quality traits in white x colour linted (*Gossypium hirsutum* L.) cotton

S. L. AHUJA, D. MONGA AND YAGYA DUTT
Central Institute for Cotton Research, Regional Station, Sirsa-125 005

To enhance yield potential and fibre quality of colour linted germplasm lines available in the National Gene Pool at CICR, Nagpur which are poor in yield and fibre quality traits,crosses were attempted between white linted local cultivars of North zone; F-505, HS-6 and 10 germplasm lines of light brown (83-1, 83-3, 1358, 1390), dark brown (LC 1-1), green colour lint (SA-140A, SA-140B, SA-3. SA-5. 84-2). These 20 crosses were evaluated during 1997-98 and 1998-99 in RBD against both the local cultivars and hybrid 'Omshankar' for lint colour in F1 generation, seed cotton yield/plant, bool weight, boll number/plant, mean fibre length, ginning out turn per cent (GOT%). The study indicated that brown lint colour (light and dark) was dominant/semi dominant over white. Green lint colour gene(s) appeared to behave with different mode of action as F_1 crosses between white linted and green lines gave greenish white/greenish, brown/green blue lint. Monogenic inheritance was observed for brown colour in F_2 segregating population. For confirmationof inheritance of green colour study in large F_2 population is suggested. Out of 20 crosses, the cross HS-6 x 83-3, a light brown linted F_1 gave more than 50% heterosis for yield/plant over all the three checks. Its boll weight (3.6 g), boll number/plant (15.5) and GOT (36.7%) was also higher than the checks. The highest GOT of 39.1 per cent and fibre length of 27.8 mm was recorded for the crosses HS-6 x 83-1 (light brown) and F-505 x 84-2 (greenish white), respectively which was more than that of any check indicating that these crosses can be exploited further in the breeding programme.

4.8
Technological performance of improved *Gossypium arboreum* cotton

MATISH CHANDRA AND S.SREENIVASAN
Central Institue for Research on Cotton Technology, Mumbai- 400 019

Cotton cultivation has always been associated with a number of risk factors but in the last dicade or so the sudden spurt in the bollworms incidence has made the situation more complicated.The unabated attack of *Helicoverpa armigera* coupled with the incidence of CLCuV (cotton leaf curl virus) has discouraged farming cummunity to grow cotton and shift to other promising crops. The vulnerability of *G.hirsutum* cotton to abiotic and biotic stresses has been one of the causative factors in bringing the *G.arboreum* cottons once again to the

central stage, as these cottons are reportedly tolerant to biotic and abiotic stresses and immune to the CLCuV.The strenuous efforts on the part of agricultural scientists have resulted in the development, identification and release of some promising *G.arboreum* strains.The improved *arboreum* strains PA-255 (Parbhani), DLSA-17 (Dharwad), *Jawahar Tapti* (Khandwa), MDL- 2463 (Mudhol), were evaluated for their physical properties (HVI & AFIS) as well as spinning potential at three different counts i.e. 16 s, 30 s and 40 s. The results obtained on fibre and yarns were compared with those of *G.arboreum* cotton RG-8 and *G.hirsutum* checks Bikaneri Narma and LRA-5166. The improved *G.arboreum* cotton were found to be *on par* in respect of the major parameters evaluated for fibre and yarn and in certain cases even superior to *G.hirsutum* cotton.

4.9
Inbreeding depression for fibre quality in *intra hirsutum* (H x H) cotton hybrids

H. J. RAJPUT, S. U. PARDESHI AND S. S. MEHETRE
All India Co-ordinated cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri-413 722

Cotton is an important commercial crop in the world. In cotton, fibre is the most important economic part. Increase in cotton production and improvement of fibre quality of cotton in India was made possible only because of the commercial exploitation of heterosis, particularly in tetraploid cotton involving primarily *Gossypium hirutum* x *G. hirsutum* crosses. An experiment was conducted with F_1 and F_2 of six *intra hirsutum* hybrids *viz.,* PKVHY-2, CAHH-468, JKHY-1, H-10, PHH-316 and RHH 1394 at Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri to study inbreeding depression for fibre quality in *intra-hirsutum* (h x h) cotton hybrids.

The increased micronaire value of F_2 generation resulted in negative inbreeding depression in PKVHY-2, CAHH-468 and RHH-1394. A better fibre quality was observed in F_1 as compared to F_2 generation. The positive inbreeding depression for micronaire value was recorded in JKHY-1, H-10 and PHH-316. The 2.5 per cent span length (mm) was reduced in all F_2 s, except JKHY-1, which resulted in negative inbreeding depression. The fibre strength (g/tex) decreased in F_2 generation of all hybrids, except RHH-1394. The fibre extensionability showed greater reduction in all F_2 s, except PHH-316 and RHH-1394, which showed negative inbreeding depression. The F_2 generation showed considerable variation in fibre quality and was inferior to F_1 hybrids, incidating superiority of F_1 hybrids for fibre quality traits thus limiting the use of F_2 seeds for commercial cultivation.

4.10
Effect of seed treatments on seed quality, seed health and storability in cotton genotypes

B. RAJESWARI, KVS MEENA KUMARI AND M. GANESH
National Seed Project, Acharya N. G. Ranga Agricultural University, Hyderabad-500 030

Cotton is an important commercial crop cultivated in Andhra Pradesh in an area of 10.22 lakh hectares with a production of 16.63 lakh bales and productivity of 2.77 q/ha. In India the crop occupies in an area of 85.77 lakh hectares with a production of 96.52 lakh bales and productivity of 1.91 q/ha. One of the major constraints for higher cotton production is the supply of quality seeds which is free from seed borne diseases. Seeds during storage undergo considerable quantitatic and qualitative changes due to various seed borne fungi and other microflora leading to loss of viability and vigour. Hence, the present study was undertaken to know the impact of seed treatments with fungicides on seed quality, seed health and storability of cotton genotypes. Fuzzy and delinted seeds of eight cotton hybrids (Bunny, NHH 44, DCH-32, Savitha, PKVHY2, LAHH4, LAHH5, DHH-11) and nine cotton varieties (LRA-5166, AK-32, LK389, LK861, L604, AKH-84635, ADB 1007, NH 1325, Surabhi) were collected from Adilabad and Guntur districts and subjected for seed health and germination by using standard techniques (ISTA, 1996). Delinted seeds of bunny hybrid and LRA 5166 variety having initial germination (>90%) SVI (2510 to 2652) and total fungal colonies (5-10%) were treated

with thiram @ 0.3%, captan @ 0.3%, Mancozeb @ 0.3%, Manzozeb @ 0.25%, thiram + carbendizim @ 0.3%, neem leaf powder extract @ 0.5% along with untreated control were packed in cloth bag and kept under ambient conditions at National Seed Project, Rajendranagar, Hyderabad for assessing the storage potential of the seeds. Observation were taken at bimonthly intervals and samples were analysed for seed microflora, seed germination and seedling vigour index. The storability was considered useful upto the time when the germination fell below minimum (65%) seed certification standard. In the present study, irrespective of hybrids and varieties tested, the fungal flora was found in fuzzy seeds (35-47%) as compared to delinted (5-10%) seeds. The germination percentage (80-95%), seedling vigour (2630) were high in delinted seeds with lesser incidence of fungal flora over fuzzy seeds. The predominant fungal in hybrids/varieties were, *Aspergillus flavus, Aspergillus niger, Alternaria macrospora, Curvularia lunata, Colletotrichum sps, Rhizopus stolonifer, Fusarium sps* and *penicillium sps,* Among the seed treatments thiram + carbendazim @ 3g/kg seed improved the storability for a period of 16 months in bunny hybrid and 12 months in LRA 5166 variety as against control (8 months). It was concluded that delinted seeds found superiority in respect of seed quality and storability.

4.11
Study of fibre quality triats in *Gossypium hirsutum* L.

JAGMAIL SINGH, R. P. SING AND PUNEET LUTHRA
Division of Genetics, Indian Agricultural Research Institute, New Delhi-110 012

Cotton is an important commercial crop in India and plays a key role in the economy of the country. Crop improvement research in cotton in India has led to the development and release of over 200 improved varieties and hybrids. Combining high seed cotton yield and superior fibre quality has been the major research objective of cotton breeding. Amongst all the fibre quality traits, fibre length has been the main consideration for making selections for improvement in fibre quality until recently. A number of varieties and hybrids having long to extra long fibre and capable of spinning from 60s to 120s counts in tetraploid cottons have been developed and are under cultivation in South and Central India. At Indian Agricultural Research Institute (I.A.R.I), New Delhi (I.A.RI.) high priority was accorded to quality improvement. The first *Gossypium hirsutum* variety spinning to 40s counts in the North zone, namely Pusa 31, was developed by I.A.R.I and was released in 1988. This was followed by the release of another variety Pusa 8-6 combining high yield and superior fibre quality.

The technological improvements in the textile industry such as high speed rotor or open end spinning require high fibre strength. Evidently fibre strength is now being accorded highest priority in breeding for superior fibre quality. Work on this aspect has been in progress at I.A.R.I for the last about one decade and several strains with high fibre strength have been identified. Six such strains, namely, P56-2, P56-6, C4-9-2-1-1, C4-9-2-1-2 and P4515-1, which showed fibre strength of 25g/tex or above during 2002-03, were evaluated in a replicated trial during 2003-04. Data on fibre quality traits were provided by CIRCOT, Mumbai. Significant genotypic differences were observed for fibre strength, fibre fineness and elongation, whereas genotypic differences were non-significant for other fibre quality traits, namely 2.5% span length, fibre uniformity and short fibre content. Fibre strength ranged from 24.3g/tex in P56-2 to 29.4g/tex in P56-4. Strain P56-6 also recorded high fibre strength of 29.2g/tex. The 2.5g/tex. The 2.5% span length ranged from 26.7 mm in P56-2 to 28.6 mm in P56-4. The ratio of fibre length to strength was 1.10 in P56-2; 0.97 in P56-4; 0.94 in P56-6; 1.07 in C4-9-2-1-2 and 1.08 in P4515-1. The lowest and below 4.0 micronaire value was observed in P56-4 being 3.7. The remaining 5 strains showed micronaire value ranging between 4.2 to 4.4 which is within accepted norms of the textile industry. These strains, thus, hold promise in terms of fibre quality in general and fibre strength in particular.

4.12
Performance of naked seeded upland cotton (*Gossypium hirsutum* L) for seed oil content and fibre quality traits

R. P. SINGH, JAGMAIL SINGH, C. B. LAL, SUNITA, SANJAY THAKUR AND K. ELAYARAJA
Division of Genetics, Indian Agricultural Research Institute, New Delhi-110 012

Cotton seed oil is an important cooking medium and refined oil is free from gossypol. About 50 lakh tonnes of seed is presently available for oil extraction from which about 4.5 to 5.0 lakh tonnes of oil could be produced. The presently available varieties have 18-20 per cent oil content which is still lower in the naked seeded genotypes. Genotypes with high oil content of 25-26 are available in the germplasm which could be utilized in breeding work to increase oil content. The use of naked seeded varieties will be an added advantage as it will eliminate the process of delinting. Keeping this in view, nine naked seeded *Gossypium hirsutum* strains developed at Indian Agricultural Research Institute, New Delhi were evaluated during 2001, 2002 and 2003 *kharif* season against the fuzzy seeded check (Pusa 8-6). Data were recorded on important characters like seed oil percentage, oil index, yield components and fibre qualtiy traits. Mean data of three year period suggested superior performance of naked seeded strains over the check with regard to seed oil content. Amongst the naked seeded genotypes, the highest seed oil content of 24.7 per cent was observed in 15-F2-1-1-1-1-2 (N) which was substantially higher as compared to Pusa 8-6 (22.3%) Mean seed oil content in 9 naked seeded genotypes ranged from 21.8 to 24.7 per cent. The fuzzy sister line of above strain, 15-F2-1-1-1-1-2 (F), however, showed the highest seed oil content of 25.8 per cent. These two strains showed identical oil index (2.2) which was also higher as compared to check (1.7). Six naked seeded strains also showed higher ginning percentage (35 to 36.9%) as compared to Pusa 8-6 (33.3%). This was expected in view of their relatively lower seed index and lower boll weight. These strains also showed good fibre quality, especially in terms of micronaire value, fibre strength and elongation percentage. Four strains showed higher fibre quality index (262.4 to 277.3) as compared to Pusa 8-6 (247.4). Thus, the naked seeded strains were found to be promising for oil content as well as fibre quality traits.

4.13
Germination status of hybrid cotton seeds produced in Tamil Nadu

A. SABIR-AHAMED AND K. VANANGAMUDI
Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore-641 003

A study was undertaken to assess the germination status of hybrid cotton seed produced in Tamil Nadu in liaison with Department of Seed Certification and Seed Testing laboratories (STL). All the details required for the study were collected from the STLs located at Coimbatore, Dharmapuri, Kanjeepuram, Tiruchirappalli, Thanjavur and Thirunelveli for the period from 1997-2002. Lot-wise germination data were grouped into five categories *viz.,* below 65%, 65-70%, 76-80%, 81-85% and above 85% and the percentage of lots falling in each category was worked out. Results of the study revealed that irrespective of STLs, about 2.5 per cent of samples were found sub-standard. There were about 13.5 per cent of samples recording a germination per cent just above the minimum seed certification standard of 65-70 per cent. However, about 36.0 and 48.0 per cent samples fell under the higher germination range of 71-80 and 81%, respectively. It was also observed that about 98.0-100.0 per cent of samples received in Dharmapuri and Thirunelveli, 65.0 per cent in Coimbatore and 37.7 per cent in Tiruchirappalli were found to be delinted seeds. In conclusion, more than 80.0 per cent of cotton seed lots produced in Tamil Nadu during 1997-2002 were of high germination standard and three has been a gradual switch over to delinted seeds.

4.14
Verification of seed germination testing substratum for cotton (*Gossypium* sp.)

V. S. GIRASE, V. D. SHENDE AND A. D. DUMBRE
Seed Technology Research Unit, Mahatma Phule Krishi Vidhyapeeth, Rahuri-413 722

The germination percentage of seed of any crop governs the seed rate per unit area. Temperature, water content and substratum for germination are the most important factors for testing the germination status of seed in laboratory. In order to verify the most optimum substraturm for germination test of cotton seed, 400 seeds of six hybrids during 2002-03 and 8 hybrids during 2003-04 were kept for germination in sand as well as between paper substratum at seed testing laboratory, MPKV, Rahuri. The total number of seedlings and length and dry weight of 10 seedlings was counted on 8th day of test in each substratum. The germination percentage, seedling length and dry weight vigour indices were estimated.

The stastical analysis of data revealed significant differences among different hybrids for seed germination and vigour indices in both the media. Pooled analysis of two years data indicated that the percentage of seed germination was numerically higher in sand media (82.%) than B. P. media (78%). The vigour index I (48 & 41) and vigour index II (961 & 833) were also numerically higher in sand media than B. P. meida, respectively. This might be due to the fact that proper water content and aeration in sand media resulted in faster germination and vigorous growth of seedlings. Though, the value of germination percentage and vigour indices were more in sand media than B. P. media, their interaction effect was non-significant. These results indicated that there was no significant effect of germination substratum/media on seed germination of cotton.

4.15
Feasibility for raising minimum seed certification standard for germination in cotton (*Gossypium* sp.)

V. D. SHENDE, V. S. GIRASE AND A. D. DUMBRE
Seed Technology Research Unit, Mahatma Phule Krishi Vidhyapeeth, Rahuri-413 722

Cotton i. e. ‘white gold’ is a very important cash crop of Indian agraians. Production and availability of quality seed is indispensible for increasing productivity and production of this crop. At present, the minimum seed certification standard (MSCS) for germination is 65 per cent. It is felt necessary to veirfy the possibility for raising the MSCS for germination in cotton. With this objective the data on seed germination of cotton samples were collected for three years from the seed testing laboratory, Pune. The data on seed germination of 919, 284, 198 samples for the years 2000-01, 2001-02, 2002-03, respectively were collected and grouped into different classes of germination. Out of which 91 per cent for 2000-01, 88 per cent for 2001-02 and 94 per cent for 2002-03 seed samples exhibited seed germination above 71 per cent. Pooled analysis of three years data indicated that 91 per cent seed samples exhibited seed germination above 71 per cent of which 59 per cent samples showed germination of more than 81 per cent. Further, 5 per cent of these seed samples of three years were collected and their reference testing was undertaken at Seed Testing Laboratory, MPKV, Rahuri during respective years. The results of reference testing indicated that on an average 88 per cent seed samples showed germination of more than 71 per cent of which 50 per cent seed samples showed seed germination of more than 81 per cent. These findings enlighten the feasibility for reaising minimum seed certification standard for germination from present 65 per cent to 70 per cent for getting high quality seed of cotton.

4.16
Fibre quality of existing cottons and future requirements in textile industries

D. N. MAKWANA
Central Institute for Research on Cotton Technology, Mumbai-400 019

Cotton is the most important commercial crop of the country occupying 8.0 million ha area and the average production is around 160 lakh bales. Though yield was the prime factor considered for development of new strains, yet for the last few years quality is given equal importance in selection process under AICCIP programme. This, in turn, had helped in developing good quality cottons in recent years.

There are three agricultural zones for cotton. North zone gives cotton of short staple, very coarse and of low strength. Central zone cottons are of medium staple, average in fineness and strength and are spinnable to 30s to 40s count. However, South zone cottons are long to extra-long, fine and prossess high strength which could be spun above 50s count. Depending upon the availability of cotton in the area and the transporation cost, the mills purchase cotton and process for desired count. CIRCOT has published Annual Cotton Update for the last eight years. It has come out with 'Fibre Quality Norms' to be used in AICCIP breeding programme for selection of the strains. It gives the required fibre parameters values corresponding to each count range varying from 6s to 120s count. Further, it is emphasised that all the three important parameters *viz.* length, fineness and strength must match as per norms for a variety or hybrid to be promoted. These norms have been strictly followed in AICCIP technical programme as well as all the projects on Technological Mission on Cotton. It has been observed that hardly 10 to 12 percent samples belonging to AICCIP or TMC on cotton satisfy the fibre quality at present. Rest of the samples lack either in micronaire or strength. However, now as the quality consideration is done at the initial stages, cotton reaching final stages will definitely have good fibre properties.

Looking at the modern machinary in textile mills, it is felt that cottons coming up in market now should have micronaire value between 3.5 to 5.0, maturity pm as 80 per cent or above and bundle tenacity between 22.0 g/t to 25.0 g/t for lower count and above 26.0 g/t for higher count. Besides fibre properties, yarn uniformity, neps, U% CSP, seed coat fragment, trash, dyeability, etc are also to be considered in the process of developing a new variety/hybrid.

4.17
Evaluation of long staple fine quality diploid cotton variety for rainfed system

RAJANI TOMAR, N. K. BISEN, PANKAJ SHAH AND G. K. KOUTU
Regional Agricultural Research Station, Jawaharlal Nehru Krishi Vidhyala, Khandwa-450 001

The Indian cotton scenario was too much dominated by *arboreums* at the time of partition with nearly 93% area in diploid cotton. After 60 years, the vast area of diploid cotton has been replaced by *G. hirsutum* varieties and hybrids mainly for yield potential and good fibre qualities. On the other hand, *desi* cotton is endowed with inbuilt resistance against sucking pests and can sustain drought condition. It has been our efforts to improve fibre properties of *desi* cotton for higher counts. To meet the exigencies, a number of genotypes have been developed by Khandwa, Parbhani, Mudhol and Dharwad centres exhibiting fibre properties with length upto 28 mm and strength above 21 g/tex coupled with a micronaire value between 4.0 and 5.0. The present study was undertaken to evaluated long linted *G. arboreum* genotypes directly on farmers field in five non-replicated trials during the year 2003-04 with a view ti identify productive superior medium fine quality *G. arboreum* genotypes for rainfed ecology. Eight varieties were tested and observations on production parameters *viz.,* plant height, no. of monopodia, no. of sympodia, no. of nodes on main stem, 20-boll weight, single boll weight, ginning percentage and seed index were recorded. Fibre quality parameters *viz.,* fibre length (mm), fibre fineness (mv), fibre strength (g/tex), uniformity ratio and FQI were also assessed. The results indicated that *arboreum* genotypes, namely, MDL-2463, J. Tapti, DLSA-17 and PA-255 showed high yield potential with stable quality performance.

4.18
Screening of medium and long staple cotton genotypes against foliar diseases

V. B. NARGUND, M. B. PATIL, G. G. RAO, S. V. HIREMATH, AND A. G. SREENIVAS
University of Agricultural Sciences, Regional Research Station, Raichur-584 101

Twenty-one cotton genotypes belonging to long staple (9) and medium staple (12) groups were screened for their resistance to foliar diseases under natural field conditions at Regional Research Station, Raichur during 2000 – 01. Bacterial blight caused by *Xanthomonas axonopodis* pv. *malvacearum* and grey mildew caused by *Ramularia areola* appeared in moderate and severe form, respectively. Among the medium staple genotypes RAMPBS – 155, Sahana, RAC – 29 and NHH – 44 recorded grade 1 for bacterial blight in 0 – 5 scale but all genotypes of long staple recorded grade 2. RAH - 100 recorded maximum grade of 4 for bacterial blight and three genotypes *viz.,* RAC - 1049, RAC - 9621 and RAC - 95121 recorded grade 3. Gray mildew in all the genotypes of both staple lengths, except RAC - 9561, recorded grade 4 in 0 - 4 scale indicating highly susceptible reaction. Thus, it was inferred that none of the genotypes had resistance to gray mildew. Alternaria leaf spot caused by *Alternaria macrospora* and rust caused by *Phakopsora gossypii* appeared only in medium staple but not in long staple genotypes and the severity was very less.

4.19
Improvement of fibre properties through introgression breeding

V. R. PATIL AND S. S. MEHETRE
All India Co-ordinated Cotton Improvement Project, Mahatma Phule Krishi Vidhyapeeth, Rahuri-413 722

Due to installation of high speed spinning mills, the demand of fibre quality requirements for textiles and spinning mills have changed. To cater to the needs of these mills, it is necessary to plan the breeding programme accordingly. Even though the variability for fibre quality traits is available in germplasm, it is not sufficient to satisfy the above requirements. One of the ways to create such variability is the introgression of gene through interspecific hybridization.

Accordingly, the crosses were made between the genetic male sterile line (GMS) of *Gossypium arboreum* x *G. anomalum* and *G. arboreum* GMS x *G. capitis viridis* during the year 2000-2001. The F_2 and F_3 populations were grown during the year 2001-2002 and 2002-2003, respectively. The lint samples of selected plants from F_3 population were tested at CIRCOT, Mumbai.

The fibre data indicated that all the fibre quality parameters were improved in F_3 progenies. Out of 24 progenies, one progeny from *G. arboreum* GMS x *G. anomalum* (164/152) recorded excellent fibre properties for the parameters *viz.,* 2.5% span length (27.24 mm), U. R. (49.5), micronaire value (3.4 u), strength (23.81 g/t), elongation (6.5%) and short fibre content (10.2%); while the progeny from *G. arboreum* GMS x *G. capitis viridis* (109) recorded 25.72 mm span length, 3.8 u micronaire value and 23.80 g/t strength. These progenies could be utilized for improving fibre qualities of cultivated *G. arboreum* varieties in future breeding programme.

4.20
A new long staple American cotton variety PH-348 (Yamuna)

D. B. DEOSARKAR AND R. H. BHOSLE
Cotton Research Scheme, Marathwada Agricultural University, Parbhani- 431 402

Cotton is the most naturally grown important fibre crop. This crop has potentials for delivering value added products. In several countries it is a major commercial crop and net earner of foreign exchange. The world average prductivity is 572 kg/ha. In India, cotton is grown under varied agro ecological situations in about 7.93 million ha. with a production of 140 lakh bales.

In Maharashtra, cotton is grown on an area of 27.93 lakh ha. with a production of 22 lakh bales. For the improvement of seed cotton yield and fibre properties the variety PH-348 (Yamuna) was released for cultivation in Marathwada region of Maharashtra in 2004. This variety is developed from the segregating population of the cross PH-92 x PH-11-9-1. The variety was tested under rainfed condition in 26 trials during 1997-2003 and it recorded 23.77 per cent higher seed cotton yield over check NH-452. In AICCP trials, PH-348 ranked first and fourth during 2001-02 and 2002-03, respectively in Central Zone with an average increase in yield of 28.69 per cent over national check LRA 5166. In addition to the yield potential, the variety had excellent fibre length (27.4 mm) which is superior to NH-452 (24.3 mm) and NH-545 (25.4 mm) and ginning outturn of 38.8% which is *on par* with NH-452.

A total of 42 adaptive trials were conducted on farmers field during 2001-02 and 2002-03 and the variety PH-348 recorded 21.42 and 14.17 per cent higher seed cotton yield over check NH-452 and NH-545, respectively. This variety can be easily identified from the other cotton varieties by observing yellow petal colour and buff anthers with oval shape bolls. These marker characters can make the job easier for seed certification.

PH-348 is free from anthracnose and parawilt tolerant to gray mildew and moderately resistant to bacterial blight. It is tolerant to moisture stress and reaction to major sucking pest and bollworm complex and is *on par* with NH-452. It is suitable for cultivation under rainfed situation and may be helpful to the marginal farmers. The seed of this variety was submitted for registration at NBPGR, New Delhi and is registered with IC No. 400219.

4.21
Genotypic variability for seedling vigour traits in cotton (*Gossypium* spp.)

V. SANTHY, R. K. DESHMUKH AND P. R. VIJAYA KUMARI
Central Institute for Cotton Research, Nagpur-440 010

A pot stuy was conducted to assess the variability among 14 genotypes comprising released varieties of *Gossypium arboreum* and *G. hirsutum* as well as germplasm lines of *G. hirsutum* for various seedling vigour traits. The traits assessed included shoot-root lenghts observed at 7 and 15 DAS (days after sowing), number of secondary roots and seedling dry weight measured at 15 DAS, height-node ratio observed at 30 DAS and days to true leaf initiation. Three replications with a minimum of ten seedlings for each were employed in each genotype for characterizing number of secondary roots, seedling dry weight and shoot-root lengths. The analysis revealed a significant variation among genotypes for all the vigour traits assessed at seedling stage till 30 DAS. The correlation analysis for various traits revealed highest positive correlation between seed weight and shoot lengths, followed by seed weight and seedling dry wight. However, days to true leaf initiation, one of the important vigour parameters, had a low correlation with initial seed weight as the major vigour traits *viz.* cotyledonary leaf area, height-node ratio and number of secondary roots had a negative correlation with initial seed weight. It was concluded that breeding strains need to be assessed for their seedling vigour trait variability and also that higher seed weight or taller seedlings do not always result in better and vigorous seedlings in most of the genotypes.

4.22
Assessment of genetic purity, identity in F_1 hybrids, their parents and F_2 population of cotton

M. C. LATHA, R. ANKAIAH, N. MANOHAR REDDY, B. GOPAL REDDY AND KVS MEENA KUMARI
National Seed Project, Acharya N. G. Ranga Agricultural University, Hyderabad-500 030

The maintenance of genetic purity of parents and hybrids of cotton is one of the most important criteria in production of good quality seeds. The genetic identity and purity assessment is a component of seed production and certification. The present investigation was taken up in order to find out specific morphological characters (DUS characters) besides other diagnostic characters so as to identify F_1 hybrids, their parents and also to detect F_2 population by field (GOT) and laboratory methods. Key morphological characters were

identified for five cotton hybrids and their parents. These characters were found distinct, uniform and stable which were least influenced by growing conditions, environment and seasons. F_2 population was also ascertained by observing segregation in morphological characters and identifying recombinant plant types. The electrophoretic banding of each genotype was unique and distinct between hybrids, their parents and F_2 population for total soluble seed proteins and useful for identification. F_2 population of different cotton hybrids segregated into plant types nearer to morphological characters of hybrids, female parent, male parent and recombinant plants which were considered as true to type, selfed plants and off types respectively for computing genetic purity. Variety identification and genetic purity assessment could be possible based on the specific morphological characters. Flow chart was developed with key characters useful for field functionaries involved in seed production/certification. All cotton hybrids recorded genetic purity above the minimum seed certification standard (90%) while F2 population recorded the genetic purity ranging from 31.5 to 43.6 per cent.

4.23
Effect of seed vigour in F_1 hybrids, their parental lines and F_2 population on growth, development and yield in cotton

M. C. LATHA, R. ANKAIAH, KVS MEENA KUMARI, N. MAOHAR REDDY AND B. GOPAL REDDY
National Seed Project, Acharya N. G. Ranga Agricultural University, Hyderabad-500 030

A field experiment was conducted to study the quantitative and qualitative characters of F_1 hybrids, their parents and F_2 population. The germination percentage and seedling vigour were less in F_2 seed lots as compared to hybrids and their parental lines. F_1 hybrids (NHH-44, Savitha, PKVHY-2, H-8 and DCH-32) were significantly superior in morpho-physiological characters of plant height, internodal length and total number of branches per plant, total dry matter production and leaf area per plant, when compared to their respective parental lines and F_2s. Among hybrids, Savitha recorded the highest number of bolls, boll weight (g), yield per plant (g) and yield per hectare (q) followed by NHH-44 hybrid, while DCH32, recorded the least. There was a significant reduction of *kapas* yield in F_2s over hybrids. The reduction was 32.4, 40.0, 29.6, 37.1and 41.2 percent in F_2s of NHH-44, Savitha, PKVHY-2, H-8 and DCH-32 respectively. The reduction of yield in F_2 generation was attributed to decrease the boll number per plant, boll weight and 100 seed weight, as a result of low seed vigour. F_1 hybrids exhibited superiority in all the qualitative characters of halo length (mm), micronaire value, bundle strength (g/tex) and uniform ratio over their parents and corresponding F_2 population. Use of F_1 seed is always beneficial to farmers to reap 13 to 27 per cent higher yield over parents, and 29.6 to 41.2 per cent over F_2 seed.

4.24
Optimization of germination, testing procedure and substratum for hybrid cotton

P. S. RAO, K. RADHIKA, R. ANKAIAH AND M. GANESH
National Seed Project, Acharya N. G. Ranga Agricultural University, Rajendranagar, Hyderabad-500 030

Cotton is an important cash crop playing a key role in the economy of India. It is cultivated in an area of 8.6 million ha with a production of 9.7 million bales having a productivity of 1.91 q ha^{-1}. Through the exploitation of hybrid vigour, nearly 75 per cent of cotton area is occupied by hybrids in India. A number of hybrids were developed and released by the private and public sector organizations. Out of the total hybrid cotton seed produced, 70-80 per cent is disposed off in the first planting season itself. The remaining seed must be stored at least for one year till the commencement of next season. Often the seed testing results of the aged seed lots vary between laboratory and field conditions. In view of this, the present investigation was taken up to find out suitable methods for seed testing in the laboratory. Fresh seed lots of eight cotton hybrids (Brahma, PCH-115,

Ajeet 55,, JKCH 666, MICH 217, JK Durga, Dharma and RCH 2) were used to determine the feasible substratum (between paper, sand and soil) for obtaining accurate and reproducible results of germination and seedling vigour in Seed Testing Laboratory at National Seed Project, ANGRAU, Hyderabad during 2002 and 2003. The germination during first and final count, seedling length, vigour and dry matter production did not exhibit variation among the substrata used. Nevertheless, sand medium recorded slightly higher values in germination and seedling growth parameters. Another experiment was conducted with fresh, one and two year-old seed lots of four cotton hybrids *viz*., NH 44, PKVHY 2, Savitha and H 8. The results indicated no difference in germination in fresh lots, irrespective of substrata used. However, variation was recorded in the aged seed lots. The present study revealed that the 'between paper method' improved the germination as well as seedling vigour of aged seed lots, whole the results with sand medium were in close agreement with the field conditions.

PEST MANAGEMENT

5.1
Reaction of F_1, F_2, F_3 and F_4 generations of interspecific crosses of cotton to grey mildew

J. H. GAIKWAD, S. S. MEHETRE AND V. L. AMOLIK
All India Co-ordinated Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri-413 722

Cotton crop is affected by major diseases like Fusarium wilt, bacterial blight, Alternaria leaf blight, root rot and grey mildew causing 5-20 per losses in seed cotton yield. Amongst these grey mildew caused by *Ramularia areola Atk* is an important disease. In India, the disease is severe only on *desi* cotton varieties i.e. *Gossypium arboreum* L. and *G. herbaceum*. Parents F_1, F_2, F_3 and F_4 generations of *G. arboreum,* GMS x *G. anomalum* and *G. arboreum,* GMS x *G. capitis viridis* were evaluated for grey mildew resistance. The segregating generation showed varying degree of reaction to grey mildew. A simple monogenic dominance was observed for susceptibility.

5.2
Screening cotton entries for sources of resistance to leafhopper, *Amrasca devastans* (Distant)

P. CHANDRAMANI, N. MURUGESAN, A. RAMALINGAM AND N. SIVASAMY
Tamil Nadu Agricultural University, Cotton Research Station, Srivilliputtur-626 125

Screening of 466 cotton breeding entires was carried out from Summer 2000 to 2003. Okra was raised as infestor row for every four rows of cotton. In Summer 2000, the entires Anjali, TKKH 1, TKH 1179, PKV Rajat, TSH 9417, ARB 8824, CNO 6, CNH 1025, CPD 612, MCU 11, SVPR 2, SVPR 3; in Summer 2001 the entires SVPR 3, MCU 11, Anjali, TKKH 1, TKH 1179, TSH 9417, 9804, 8219, 8235, 8352; in Summer 2002 the entires RAH 111, CNH 2124, RHC 940, RAC 9553, PKV Rajat and in Summer 2003 the entires SVPR 2, TSH 9704, GJHV 392, GJHV 360, GSHV 97/13, RAC 1094, GSHH 19/59, CNH 301 were found to be resistant to leafhopper. The entires, Anjali, PKV Rajat, CNH 1025, MCU 11, SVPR 2 and SVPR 3 were short listed as resistance source material for leafhopper.

5.3
Influence of weather factors on the incidence of *Amrasca devastans* (Distant) in cotton

N. MURUGESAN, A. KAVITHA, P. CHANDRAMANI AND N. SIVASAMY
Tamil Nadu Agricultural University, Cotton Research Station, Srivilliputtur-626 125

Multiple regression analysis of leafhopper population on plants under different levels of protection revealed that maximum temperature and wind velocity had a positive influence on the nymphal population of *Amrasca devastans* (Distant) while sunshine hours had the opposite effect in the plots that were protected during vegetative phase of the crop alone. While sunshine hours had the opposite effect (R^2=0.9249). On plants protected during reproductive phase, wind velocity and rainfall resulted in negative influence (R^2=0.3785). Leafhopper population, on plants under complete protection, increased with the increase in maximum temperature (R^2=0.5264). Similar was the effect with maximum temperature on untreated plants (R^2=0.7528). It was worth mentioning that a greater influence of weather factors was observed on nymphal population of *A. devastans* on the plants protected during vegatative phase alone (R^2=0.9249) than those under complete protection during as well as reproductive phases of the crop (R^2=0.7528).

5.4
Identifying resistant source material for cotton stem weevil, *Pempherulus affinis* Fst.

P. CHANDRAMANI, N. MURUGESAN, N. SIVASAMY, A. RAMALINGAM AND R. VIMALA
Tamil Nadu Agricultural University, Cotton Research Station, Srivilliputtur-626 125

Screening of 466 cotton preliminary and advanced breeding entires was carried out from summer 2000 to 2003. In summer 2000, the entires 8219, 9360, TSHH 9417, TKKH 1; in summer 2001 the entries SVPR 3, MCU 11, Anjali, TKKH 1, TKH 1179, TSH 9417, 9804, 8219, 8235, 8352; in summer 2002 the entires SVPR 3, MCU 11, Anjali, TKKH 1, TKH 1179, TSH 9417, 9804, 8219, 8235, 8352 and in summer 2003 the entires TSH 9701-1 were found to be resistant to stem weevil. The entires, TSH 9417 and TKKH 1 were consistently resistant to stem weevil, *Pempherulus affinis* Fst. The entires, TKKH 1, TSH 9417 and GSHV 97/13 showed multiple resistance to leafhopper, *Amrasca devastans* (Distant) and stem weevil.

5.5
Role of vesicular arbuscular mycorrhiza (VAM) in the management of *Meloidogyne incognita* in cotton, *Gossypium hirsutum*

K. K. VERMA AND R. K. JAIN
Department of Nematology, CCS Haryana Agricultural University, Hisar-125 004

A screenhouse study was conducted to test the efficacy of vesicular arbuscular mycorrhiza (VAM)+fungus,*Glomus fasciculatum* against root-knot nematode, *Meloidogyne incognita* @ $1J_2$/g soil infecting cotton (var. H-777) at three levels of phosphorus application *viz.,* 0, ½ of the recommended level and recommended level. The data recorded 60 days after nematode inoculation revealed that plant growth parameters of cotton *viz.,* shoot length,fresh and dry shoot and root weight were higher and significantly better when *G. fasciculatum* was applied in *M. incognita* infested soil. Similarly, number of galls, number of egg masses and final population of J_2 in the soil was lower and significantly reduced by application of VAM as compared to untreated check at each level of P application. However, these effects were more pronounced when no phosphorus was applied i.e. at zero level of P application, which showed 80.0, 116.0 and 105.5 galls/plant by VAM application as compared to 173.3, 177.5 and 155.3 galls in nematode alone at 0, ½ of the recommended and recommended level of P, respectively. The reproduction factor of nematode was also lowest when VAM was applied in soil receiving no phosphorus as compared to untreated check and other levels of phosphorus application.

5.6
Evaluation of newer insecticide molecules against *Earias* sp. and *Pectinophora gossypiella* in rice fallow *hirsutum* cotton

P. CHANDRAMANI, N. MURUGESAN AND N. SIVASAMY
Tamil Nadu Agricultural University, Cotton Research Station, Srivilliputtur-626 125

In summer rice fallow tracts leafhopper, stem weevil and bollworms are the key insect pests. To tackle these pests insecticides *viz.,* emamectin benzoate at 8.0 g, 9.5 g and 11.0 g a.i./ha, omite (600 g a.i./ha)+cypermethrin (60 g a.i./ha) and spinosad (75 g a.i./ha) were evaluated in comparison with a standard check (endosulfan 700 g a.i./ha) and untreated check during summer 2003. Emamectin benzoate at 9.5 g (9.85%) and 11.0 g a.i./ha (9.18%), omite+cypermethrin (9.87%), spinosad (9.97%) and standard check (10.30%) were equally effective in reducing the *Earias* sp. damage. Emamectin benzoate at 8.0 g a.i./ha was better than untreated check but inferior to its higher doses. The per cent locule damage by *Pectinophora*

gossypiella varied from 7.54 to 8.91 among the best treatments whereas it was 12.84% in emamectin benzoate at 8.0 g a.i./ha, followed by untreated check (16.91%).

5.7
Evaluation of foliar insecticides and *Pseudomonas fluorescens* against *Amrasca devastans* (Distant) in cotton

N. MURUGESAN, A. KAVITHA, P. CHANDRAMANI, M. SURIACHANDRASELVAN AND N. SIVASAMY
Tamil Nadu Agricultural University, Cotton Research Station, Srivilliputtur-626 125

Foliar applications of acephate 70 sp (0.075%), *Pseudomonas fluorescens*-PF-1 (5 g/l), carbosulfan 25 DS (0.05%), carbosulfan 25 EC (0.05%), dimethoate (0.03%), ethofenprox 10 EC (0.02%), imidacloprid 17.8 SL (0.009%), monocrotophos (0.036%), neem oil (2%), and phosalone 35 EC (0.07%) were evaluated against *Amrasca devastans* and bollworms, along with an untreated check. Imidacloprid was the most effective treatment with 83.67 per cent reduction in leafhopper population, followed by monocrotophos and *P. fluorescens* with 76.77 and 70.58 per cent reduction, respectively. Bad *kapas* content was 5.57, 7.05, 9.64, 9.93 and 10.36 per cent in imidacloprid, acephate, *P. fluorescens,* phosalone and ethofenprox, respectively. Imidacloprid (1180 kg/ha), phosalone (1080 kg/ha) and acephate (1066 kg/ha) were equally effective with higher yield than all other treatments including untreated check (525 kg/ha). Benefit/cost ratios were : 3.23, 3.17, 2.98, 2.55, 2.54, 1.54, 0.81, 0.72, 0.47 and 0.25 for monocrotophos, *P. fluorescens,* acephate, phosalone, dimethoate, imidacloprid, carbosulfan 25 EC, carbosulfan 25 DS, neem oil and ethofenprox, respectively.

5.8
Efficacy of newer insecticides against bollworms of cotton

A. S. YADAV, V. K. SHRIVASTAVA AND S. P. S. TOMAR
Jawharlal Nehru Krishi Vishwa Vidhalaya, Regional Agricultural Research Station, Khandwa-450 001

Bollworms (*Helicoverpa armigera, Pectinophora gossypiela* and *Earias spp.*) are the most damaging pests of cotton. A field experiment was conducted to know the efficacy of three newer insecticides *viz.,* indoxacarb 14.8 SC @ 75 g a.i./ha, BTk (Halt) @ 1.5 kg/ha, spinosad 48 SC @ 75 g a.i./ha and three commonly used insecticides *viz.,* profenophos 50 SC @ 2000 ml/ha, chloropyriphos 20 EC @ 1000 ml/ha and endosulfan 35 EC @ 2000 ml/ha against bollworms of cotton during 2003-04 at the farmers field. The results indicated that BTk, spinosad and indoxacarb provided effective of control bollworms in terms of squares, green bolls, open bolls and locule damage against the control. However, BTk (Halt) recorded lowest damage on squares (12.20%), green bolls (13.21%), open bolls (14.98%) and locules (16.12%). Spinosad treated plots had 12.35, 13.55, 16.83 and 17.99 per cent damage in squares, green bolls, open bolls and locules, respectively. Seed cotton yield in spinosad and indoxacarb treated plots was 16.28 and 16.16 q/ha, respectively as compared to 8.85 q/ha in the control.

5.9
Mortality of predatory Coccinellids–result of insecticidal pollution

R. K. CHOUDHARY, V. K. GARG, YOGESH PATEL AND A. S. YADAV
Jawaharlal Nehru Krishi Vishwa Vidhalaya, Regional Agricultural Research Station, Khandwa-450 001

In India, approximately 50 per cent pesticide is consumed only in cotton. Due to the injudicious use of pesticides the problems like development of resistance in insects, pest resurgence and environmental pollution have emerged as serious problems. IPM is one of the tools to fight with such problems and biological control is one of the important components. Effect of recommended insecticides on *Coccinella septumpunctata* and *Minochilus sexmaculata* was observed at Regional Agriculture Research Station, Khandwa during *kharif* 2001-02 on cotton variety J. K.-4. The insecticides *viz.,* phosphomidon 85 EC, monocrotophos 36 SL, methyl demeton 25 EC, endosulfan 35 EC, neem oil @ 4 ml/lit. and NSKE 5% were evaluated. Phosphomidon 85 EC

(96%), monocrotophos 36 EC (96%) and methyl demeton 25 EC (93%) caused graeter mortality of Coccinellids than endosulfan (43%), neem oil (31%) and NSKE (25%).

5.10
Studies on the persistent toxicity of imidacloprid 17.8% SL against cotton aphid, *Aphis gossypii* (Glover)

M. SUGANTHY, S. KUTTALAM AND S. CHANDRASEKARAN
Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore-641 003

Experiments were carried out during 2001 and 2002 at Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore on the persistent toxicity of Confidence (imidacloprid 17.8% SL) against cotton aphid, *Aphis gossypii* (Glover). The results revealed 100 per cent mortality of aphid upto 7 and 9 days after treatment (DAT) at 25 and 50 g a.i./ha, respectively. More than 50 per cent mortality was observed at 15 and 17 DAT at 25 and 50 g a.i./ha, respectively. There was a progressive reduction in the mortality of aphid with the time and the effect of imidacloprid 17.8% SL persisted for 25 and 29 DAT at 25 and 50 g a.i./ha, respectively, while it was 25 days in imidacloprid 200 SL at 25 g a.i./ha. The order of relative efficacy of the insecticides based on the persistent toxicity index (PTI) was : imidacloprid 17.8% SL at 50 g a.i./ha > imidacloprid 200 SL at g a.i./ha > imidacloprid 17.8% SL at 25 g a.i./ha.

5.11
Bioefficacy of Confidence® (imidacloprid 17.8% SL) against sucking pests of cotton

M. SUGANTHY*, S. KUTTALAM AND S. CHANDRASEKARAN
Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore-641 003

Two field experiments were carried out to evaluate the bioefficacy of Confidence® (imidacloprid 17.8% SL), as foliar application against sucking pests of cotton. In experiment I, mean percentage reduction of leafhopper over control after first spray was in the range of 65.86 to 82.40 and it was 72.25 to 94.30 after second spray. In experiment II, the range was 53.53 to 82.01 and 49.16 to 88.30 per cent after first and second spray, respectively. The per cent reduction of thrips over control was 67.61 to 91.97 per cent after first spray and 85.62 to 97.49 per cent after second spray in the first field trial and it was 43.91 to 75.72 and 73.33 to 93.94 per cent after first and second spray, respectively. The mean per cent reduction of whitefly over control was 58.24 to 87.66 after first spray and 66.32 to 90.72 per cent after second spray in the field experiment I and it ranged between 47.99 and 79.29 after first spray and 62.20 to 92.94 per cent after second spray in the field experiment II. Confidence @ at 25 g a.i./ha was highly effective against sucking pests of cotton and was *on par* with Confidor® (imidacloprid 200 SL) at 25 g a.i./ha.

5.12
Effect of some newer insecticides on bollworms incidence and yield of seed cotton in Haryana

R. K. SAINI, H. R. ROHILLA, PALA RAM AND B. S. CHHILLAR
Department of Entomology, CCS Haryana Agricultural University, Hisar-125 004

Field efficacy of some newer insecticides was tested during 2003 at the Research Farm of Department of Entomology, CCS Haryana Agricultural University, Hisar against bollworms, namely, spotted bollworms (*Earias insulana* and *E. vittella*), pink bollworm (*Pectinophora gossypiella*) and American bollworm (*Helicoverpa armigera*). The trial was conducted on cotton variety H 1098 sown on May 10, 2003 in a randomized block design keeping three replications. A plot size of 29 m^2 was kept with a row to row and plant to plant spacing of 1 m and 30 cm, respectively. The insecticides tested were : profenophos (Celcron 50 EC) at 500, 625, 750 and 875 g a.i., profenophos (Profex 50 EC) at 875 g a.i., profenophos (Curacron 50 EC) at 875 g a.i., quinalphos (Ekalux 25 EC) at 560 g a.i., fipronil 5% SC at 50, 75, 100 and 200 g a.i., thiodicarb (Larvin 75 WP) at 375, 470 and 560 g a.i., indoxacarb 14.5 SC and indoxacarb 15 EC, each at 75, 100 and 150 g a.i.,

carbaryl (Sevin 50 WP) at 1250 g a.i., cypermethrin (Ripcord 10 EC) at 62.5 g a.i. and deltamethrin (Ezeetab 25% deltamethrin Tablet) at 12.5 g a.i./ha. Five sprays of different insecticides were given at 10-12 days interval between last week of August and first week of October. The results indicated that deltamethrin, thiodicarb (at 560 g a.i./ha) and cypermethrin sprayed plots recorded significantly low incidence of bollworms than those sprayed with quinalphos. Further, profenophos at 875 g a.i., fipronil 5% SC at 200 g a.i., thiodicarb at 375 and 470 g a.i., indoxacarb at 150 g a.i., and carbaryl at 1250 g a.i./ha were as effective as quinalphos in reducing bollworms incidence. Highest seed cotton yield was recorded in deltamethrin at 12.5 g a.i. (16.8 q/ha), followed by profenophos (Curacron 50 EC) at 875 g a.i. (16.2 q), indoxacarb 15 EC at 150 g a.i. (16.0 q), indoxacarb 14.5 SC at 150 g a.i. (15.8 q), thiodicarb at 560 g a.i. (15.8 q) and profenophos (Celcron 50 WP) at 875 g a.i./ha. On the basis of reduction in bollworms incidence and increase in seed cotton yield it was concluded that thiodicarb at 560 g a.i., indoxacarb (14.5 SC or 15 EC) at 150 g a.i. and deltamethrin at 12.5 g a.i./ha were the best treatments. Indoxacarb (14.5 SC or 15 EC) at 100 and 150 g a.i./ha provided excellent cotnrol of *H. armigera* giving larval mortality of 87-100 per cent, followed by thiodicarb at 470 and 560 g a.i./ha with larval mortality of 78-86 per cent. Different treatments reduced population of common spiders by 24.5-48.0 per cent over control, with an overall mean reduction of 35.6 per cent.

5.13
Evaluation of efficacy of Pride (acetamiprid) 20 SP for the control of whitefly, *Bemisia tabaci* (Genn.) on American Cotton

DULCHA S. BARAR AND NAVEEN AGARWAL
Panjab Agricultural University, Regional Station, Bathinda-151 001

Three dosages of Pride (acetamiprid) 20 SP i.e. @ 100, 150 and 200 g/ha were compared with already recommended insecticides, *viz.,* Metasystox (oxydemeton methyl) 25 EC @ 750 ml/ha, Hostathion (triazophos) 40 EC (@ 1500 ml/ha and Phosmite (ethion) 50 EC @ 2000 ml/ha for the control of whitefly, *Bemisia tabaci* (Genn.) on American cotton during *kharif,* 2003. Hostathion 40 EC and Phosmite 50 EC @ 1500 and 2000 ml/ha, respectively are also recommended for the control of bollworm complex in cotton. Pride 20 SP @ 150 and 200 g/ha, being *on par* with each other proved significantly better for the control of *B. tabaci* upto 7 days after spary. Maximum reduction in *B. tabaci* population (-50.00 to -77.67%) occurred only one day after spray. After that its population showed an increasing trend though remained at a low level than that observed before spray in all the treatments, except Metasystox 25 EC where it showed an increasing trend 3 days after spray. A decrease of 38.16, 34.83, 19.13, 9.89 and 9.25 per cent in *B. tabaci* population was observed 7 days after spray in treatments with Pride 20 SP @ 200 g/ha, Pride 20 SP @ 150 q/ha, Hostathion 40 EC @ 1500 ml/ha, Phosmite 50 EC @ 2000 ml/ha and Pride 20 SP @ 100 g/ha, respectively. However, an increase of 55.38 and 71.25 per cent in whitefly population was observed 7 days after spray in treatments with Metasystox 25 EC @ 750 ml/ha and untreated control, respectively.

5.14
Population dynamics of key pests of cotton at farmers fields in Madhya Pradesh

S. P. S. TOMAR, V. K. SHRIVASTAVA AND A. S. YADAV
Jawaharlal Nehru Krishi Vishwa Vidhayala, B. M. College of Agriculture, Khandwa-450 001 (M. P.), India

Study on the activities of key pests of cotton was undertaken at farmers fields of M. P. during 2003-04. Five species *viz., Amrasca biguttula biguttula, Aphis gossypii, Earias spp., Helicoverpa armigera and Pectinophora gossypiella* attained the status of major pests. Other three species attacked the crop as minor pests as these never caused severe damage. The incidence of *Lariomyza spp.* was observed in the month of July between 26th and 30th SMW. The *Aphis gossypii* started its activity from mid July (28th SMW) till the end of Sept. (40th SMW). Infestation of *Amrasca biguttula biguttula* was more between 28th and 43rd SMW but peak activity was observed from last week of July to mid August. *Thrips tabaci* remained active from 29th to 43rd SMW but was at low level. The activity of whitefly was noticed in the month of August and continued till end of October

at low level. Among the bollworms complex, *Earlias spp* activity was observed from mid July till end of November and peak activity was at highest level in September. Similarly, the incidence of *Helicoverpa armigera* was observed from last week of July to mid January. Maximum activity of this pest was noticed in the month of September. Activity of *Pectinophora gossypiella* was recorded from October to December.

5.15
Screening of *intra hirsutum* cotton hybrids for insect pest reaction

MAHABALESHWAR HEGDE AND J. M. NIDAGUNDI
University of Agricultural Sciences, Agricultural Research Station, Siruguppa-583 121

A field experiment wad undertaken to screen 38 *intra-hirsutum* hybrids from private as well as public sector for insect pest reaction at Agricultural Research Station, Siruguppa during 2002. The hybrids differed significantly for insect reaction and also to yield. Significantly lower population of cotton leafhopper (11.48/top 3 leaves) was recorded on Sandocot 35. The lowest per cent *Earias* damage was observed on Nandi 12 (3.06%) which differed significantly from the rest of the hybrids. The next best hybrid with respect to per cent *Earias* damage was DHH 11 (4.21%), which was *on par* with Karna 119 (4.87%) and significantly superior to the rest of the hybrids. Per cent *Earias* damage was 5.54 in GK 111, which was *on par* with Brahma (5.05%) and significantly superior to the remaining hybrids. Per cent green boll damage was lowest in Amarteja (3.77%), which was *on par* with JKSH 99 (3.87%), Jyothi VCH 220 (4.63%) and significantly superior to rest of the hybrids. The good opened bolls were highest in JKSH 99 (42.6/plant), *on par* with Amarteja, Jyothi VCH 220 and significantly superior to rest of the treatments. Bad opened bolls were lowest in Indam 227 (3.3/plant) and highest in NHH-44 (7.1/plant). The highest yield was obtained in JKSH 99 (17.12 kg/ha), *on par* with Shri Krishna 306 (1377 kg/ha), NHH-44 (1364 kg/ha), Amarteja (1650 kg), Viswanath (1604 kg/ha) and significantly superior to rest of the hybrids in the trial.

5.16
Evaluation of inter-specific cotton hybrids for insect pest resistance

MAHABALESHWAR HEGDE AND J. M. NIDAGUNDI
University of Agricultural Sciences, Agricultural Research Station, Siruguppa-583 121

A field experiment was conducted to evaluate 16 inter specific (H x B) cotton hybrids for insect pest reactions at Agricultural Research Station, Siruguppa during the year 2002. The cotton leafhopper population ranged from 10.63 to 15.55/top three leaves, but there was no statistical difference in leafhopper population among the hybrids tested under this trail. The hybrids differed significantly over spotted bollworm damage. Lowest damage of 5.1 per cent was recorded in hybrid 6188, which was *on par* with Varalakshmi (5.11%), DHB 290 (5.44%), DCH-32 (6.2%) and differed significantly with the rest of the hybrids. The maximum spotted bollworm damage was noticed in Kashinath. Arati proved to be superior over other hybrids by recording signifncalty lowest per cent (5.76%) green boll damage. The next best hybrid was DHB 105, followed by Kashinath, DCH-32, Paras Lakshmi and hybrid 6118. All the other hybrids recorded more than 10% green boll damage. The maximum GOB of 31/plant was recorded in Kahinath, which was *on par* with hybrid 6118 (30.3/plant) and significantly superior to rest of hybrids. Bad opened bolls ranged from 3.9 to 7.5/plant. The lowest was recorded in DHB-105 and that of highest in Kahinath and Arati. Significantly highest cotton yield was recorded in Paras Lakshmi, which was superior to rest of the treatments. The DHB-292 recorded higher yield (822 kg/ha) was *on par* with DCH-32, DHB-806 and significantly superior to rest of the treatment.

5.17
Effect of weather parameters on the occurrence of diseases in cotton

D. S. TOMAR, P. P. SHASTRY AND G. K. KOUTU
Jawaharlal Nehru Krishi VishwaVidhalaya, Regional Agricultural Research Station, Khandwa-450 001

Cotton, the dominant sector of Indian agriculture, plays a vital role in the economy. Among the various factors affecting cotton yield, the diseases have an important role. In Nimar region (M. P.) Alternaria blight caused by *Alternaria macrospora,* Myrpthecium blight caused by *Myrothecium roridum* and New Wilt are major diseases. The influence of weather factors on the occurrence of various diseases on cotton was studied. The maximum increase in the intensity and incidence of both Alternaria blight and Myrothecium blight seemed to be influenced by the changes in maximum temperature. A maximum temperature between 28 and 30°C was observed to be the most favourable for the disease which was seconded up in the 39th std m. w. New Wilt disease was initiated. It continued to increase till the maximum temperature ramained above 31.0°C. The rate of change of maximum temperature had a marked effect on the increase of New Wilt.

5.18
Influence of fungicides and bio-control agents on the germination of cotton in field

D. S. TOMAR, P. P. SHASTRY AND G. K. KOUTU
JJawaharlal Nehru Krishi VishwaVidhalaya, Regional Agricultural Research Station, Khandwa-450 001

A field experiment was conducted to assess the influence of fungicides *viz.,* Vitavax - 200 FF @ 2.5 ml, 3.0 ml/kg seed, Vitavax - 200 wp @ 2.5 g, 3.0 g/kg seed, Carbandezim @ 2.0 gm/kg seed and bio-control agents *viz. Trichoderma viride* @ 10.0 g/kg seed soil application of *T. viride* was made @ 2.5 kg/ha. Soil admendment with FYM (*T. viride*) @ 2.5 tons/ha., and Neem cake @ 2.0 tons/ha. was studied with respect to the germination of cotton seed in field. All the chemicals and bio agents, except soil admendment with FYM (*T. viride*), were found to significantly increase germination. Vitavax @ 3.0 g/kg seed, (78.6%), Vitavax @ 2.5 ml, 3.0 ml/kg seed and Vitavax 200 WP @ 2.5 g, 3.0 g/kg seed (66.0%) were found to be most effective, followed by Vitavax @ 2.5 ml/kg seed, carbandezim (64.6%) and soil application of *T. viride* and Neem cake (63.3%). The best treatment was Vitavax-200 wp @ 3.0 g/kg seed which increased the germination significantly over all other treatment where the increase in germination percent over control was 26.2%, followed by Vitavax @ 3.0 ml/kg seed (13.18%) and Vitavax @ 2.5 g/kg seed (12.12%).

5.19
Interaction effect of fertilizer levels and pest management methods on cotton crop phenology and bollworms damage

S. VENNILA, V. K. BIRADAR, P. R. PANCHBAHAI, J. G. GADPAYLE, M. S. RAMETKE, S. A. DEOLE AND P. P. KARNAJAKAR
Central Institute for Coton Research, Nagpur-440 010

Varietal growth dynamics influenced by crop management practices affects cotton crop's ability to compensate for herbivor damage. Present study investigated the interaction effects of fertilizer levels and pest management method on the amount of damage by bollworms and ability of cotton plant to compensate for damage under rainfed conditions of India. Experments were conducted on cotton cultivar LRA 5166 having four replicated five fertilizer levels (farm yard manure @ 10t/ha (FYM) alone, FYM +60 : 30 : 30 NPK/ha, FYM + 90 : 45 : 45 NPK/ha, 60 : 30 : 30 NPK/ha and 90 : 45 : 45 NPK/ha) and two pest management (need based protection and unprotected) methods. *Helicoverpa armigera* (Hubner) damage was signifcantly low under organic manure as comapred to synthetic fertilizers. Boll damage was 55 and 25 per cent under unprotected and protected situations, respectively. LRA 5166's compenstation ability for loss of fruiting structures was strongly

related to square production (r = 0.87). Compensation for fruiting structures lose due to bollworms under spray situation was more, while it decreased with increasing damage under unprotected conditions. Interaction effect between fertilizer levels and control methods indicated no differences for sprayed and unsprayed situation at higher synthetic fertilizer doses. Yield accrued with oragnic manuring cum synthetic fertilization (FYM @ 10 t/ha + 60 : 30 : 30 NPK/ha) was found to be optimum.

5.20
Influence of plant protection and ecological mangaement of Asiatic rainfed cotton var. Jawahar Tapti on bollworms

R. K. CHOUDHARY, S. K. KHAMPARIA, ASHISH UPADHYAY, V. K. GARG AND YOGESH PATEL
Jawaharlal Nehru Krishi VishwaVidhalaya, Regional Agricultural Research Station, Khandwa-450 010

Bollworms (*Earias* spp., *Helicoverpa armigera* and *Pectinophora gossypiella*) are reported to cause 20-50 per cent damage to Astatic cotton, *Gossypium arboreum* L. Field studies were conducted to investigate the feasibility of ecological management integrated with plant protection through the application of crop production components *viz.* plant protection, nutrient management and weed control on bollworms complex on variety Jawahar Tapti at Regional Agriculture Research Station, Khandwa during 2000-2002. Maximum yield (1600 kg/ha) with lowest damage to square, bolls and locules was observed in the crop grown with fertilizer + weed control + plant protection.

5.21
Trichoderma spp: a potential hyperparasite on *Rhizoctonia solani* Kuhn

R. C. UKEY, G. T. BEHERE, D. L. WASULE AND S. R. WADYALKAR
Central Institute for Cotton Research, Nagpur, 440 001

Trichoderma viride-1 gave the highest (47.55 mm) inhibition zone against *Rhizoctonia solani* (Kuhn) which causes root rot of cotton. The same strain showed 81.66 per cent healthy germination in blotter with 6.30 cm and 10.30 cm more length of the plumule and radical, followed by other strains of the same antagonist fungus. In pot culture, 90.83 per cent recuction in root not over control was observed. There was an increase in shoot and root length by 81.14 and 76.50 per cent, respectively as compared to control. In the field test, the seed treatment of cotton hybrids, JKH-Y-1, H-8, H-4 and one diploid cotton, AKH-4 with *Trichoderma viride* showed 100 per cent reduction of root rot over control.

5.22
Evaluation of antagonistic organisms in the management of sucking pests of cotton

S. MOHAN, M. SUGANTHY AND N. NAGAPASUPATHI
Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore-641 003

Field experiments were conducted at Tamil Nadu Agricultural University to evaluate the efficacy of the antagonistic organisms for the management of cotton aphid (*Aphis gossypii*), leafhopper (*Amrasca biguttula biguttula*), thrips (*Thrips tabaci*) and whitefly (*Bemisia tabaci*) attacking cotton. The treatments included seed treatments with *Pseudomonas fluorescens* (10 g/kg), seed treatment with *Trichoderma viride* (4 g/kg), FYM + seed treatment with *Pseudomonas fluroescens* (10 g/kg), FYM + seed treatment with *Trichoderma viride* (4 g/kg), FYM + seed treatment with imidacloprid 70 WS (7.5 g/kg seed) + seed treatment with *P. fluorescens* (10 g/kg) + seed treatment with *T. viride* (4 g/kg), seed treatment with imidacloprid 70 WS (7.5 g/kg seed) and an untreated control. The results revealed that among all the treatments, FYM + imidacloprid 70 WS (7.5 g/kg seed) + seed treatment with *P. fluorescens* (10 g/kg) + seed treatment with *T. viridi* (4 g/kg) recorded its

superiority with the lowest population (0.08 to 1.92/plant), followed by seed treatment with imidacloprid 70 WS (7.5 g/kg seed) (0.09 to 2.16/plant). Seed treatment with *P. fluorescens* (10 g/kg) and treatment with *T. viridi* (4 g/kg) were found to be *on par*. Similarly, seed treatment with FYM + *P. fluorescens* (10 g/kg) and seed treatment with FYM + *T. viridi* (4 g/kg) were found to be *on par*. All the treatments were superior over untreated control. Leafhopper and whitefly also followed similar trend.

5.23
Cotton pink bollworm management using Pb Rope® L mating disruptant

B. V. PATIL, M. BHEEMANNA, V. ANAND KUMAR AND S. G. HANCHINAL
University of Agricultural Science, Regional Agricultural Research Station and College of Agriculture, Raichur-584 101

Integrated pest management through mating disruption technique using sex pheromones offers a practical and ideal apprach to combat cotton pink bollworm, *Pectinophora gossypiella* (Saunders). Large scale field trails during 2001-02 and 2002-03 at farmers fields were undertaken to evaluate the efficacy of Pb Rope ® L (sex pheromone formation of PBW manufactured to Shin-Etsu Chemical Co. Ltd., Japan and supplied by New Chemi Industries Ltd. Mumbai, India) applied at pinsquare stage of the cotton at 200 and 300 dispensers/ha dosage and compared with a control plot. Average rosetted flowers (2-4%), PBW damage (10-13%), bad opened bolls (7-9%) were significantly less in Pb Rope L treated plots as compared to control plot. Seed cotton yield was higher in Pb Rope L treated plots (21 qt/ha) as compared to control plot (18 qt/ha). Pb Rope L plot recorded 35-40% higher net profit as compared to control plot. Based on two seasons study, it was concluded that Pb Rope ® L at 200 dispensers/ha applied during pinsquare stage effectively checked PBW damage and increased quality seed cotton with higher net profit.

5.24
Antifungal activity of some plant extracts against root rot (*Rhizoctonia solani*) pathogen

SURENDER SINGH, J. P. S. YADAV AND M. S. CHAUHAN
Department of Plant Pathology, CCS Haryana Agricultural University, Hisar-125 004

The efficacy of various plant extracts was tested on cotton root rot incidence. Plant extracts of six plant species (Aak, Datura, Eucalyptus, Garlic, Jatropha and Neem) showed fungitixic properties against root rot pathogen (*Rhizoctonia solani*) when tested under green house conditions at three concentrations (25, 50 and 100%). All the plant extracts significantly reduced root rot incidence, except Eucalyptus. Minimum root rot incidence (24.44%) as compared to 63.43% was recorded for neem leaves extract, which differed non-significantly from other extracts.

5.25
Multiple disease resistant cotton genotypes

S. N. CHATTANNAVAR, A. S. SHARMILA AND B. M. KHADI
University of Agricultural Sciences, Agricultural Research Station, Dharwad-580 007

Three hundred and eighty five genotypes consisting of hybrids and varieties were screened in field which were sandwiched cotton genotypes, i. e., Abaditha and Jayadhar susceptible to Bacterial blight and Alternaria blight and Grey mildew, respectively. Four artificial sprays of these pathogens were given at 30 days after sowing at an interval of 15 days. Screening for diseases resistance was made by following 0-4 scale, Sixteen genotypes showed resistance to Alternaria blight and Grey mildew, while 71 genotypes showed resistant reaction to Alternaria blight and Bacterial blight. With respect to Grey mildew and Bacterial blight, four genotypes (RB

539, ARB 760, RST 2315 and NALA 2463) exhibited resistance. However, for all the three diseases, 16 genotypes, i. e. ARB 755, RST 2315, PAIG 127, JLA 794, GAM 107, NA 529, KWA 23, PA 405, DLSA 17, CINA 17, GAM 69, Mahabeej DH 999, CISAH 3, FMDH 3, GBhv 222, DDhc 20 were found to have multiple disease resistance.

5.26
Bioefficacy of phosphamidon on cotton leafhopper

MAHABALESHWAR HEGDE, J. M. NIDAGUNDI, AND D. P. BIRADAR
University of Agricultural Sciences, Agricultural Research Station, Siruguppa-583 121

A field trial was conducted to evaluate bio-efficacy of phosphamidon 40SL at different doses against leafhopper on cotton. Monocrotophos 36 SL was used as standard check. The observations were recorded on top three leaves of ten plants and averaged to top three leaves in case of leafhopper. Good opened bolls and bad opened bolls were counted on ten plants and averaged to per plant. Results revealed that there was no significant difference among the treatments during pretreatment counts. Phosphamidon 40SL @ 200 g.ai/ha recorded high leafhopper population and was *on par* with untreated check. Phosphamidon 40SL @ 300 g.ai/ha recorded significantly lower population of leafhopper, *on par* with Phosphamidon 85 SL @ 300 g.ai/ha and inferior to higher doses of the same chemical. Phosphamidon 40 SL @ 400 g.ai/ha recorded significantly lower population of leafhopper and inferior to standard check Monocotophos 36 SL. Phosphamidon 40SL @ 500 g.ai/ha recorded significantly lower population of leafhopper and was *on par* with standard check monocrotophos 36SL. Good opened bolls were significantly higher in phosphamidon 40 SL @ 400 g.ai/ha was *on par* with phosphamidon @ 500, 300 g.ai/ha and monocrotophos 36 SL. The highest yield of 2523 kg seed cotton was recorded with phosphamidon 40SL @ 400 g.ai/ha and was *on par* with phosphamidon 40SL @ 300, 500 g.ai/ha and monocrotophos 36SL.

5.27
Efficacy of Thiamethoxam 25 WG against sucking pests in cotton

S. V. KRISHNAMOORTHY AND S. SUBRAMANIAN
Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore-641 003

Thiamethoxam 25 WG supplied by Tagros Chemical Limited, Chennai were tried against sucking pests *viz.,* aphid and jassid at two test doses. Study was undertaken at Cotton Research Station, Srivilliputtur during Summer 2002. Trial was laid out in RBD with four replications. Five treatments *viz.,* thiamethoxam 25 WG @ 25 and 50 g ai/ha, imidacloprid 200 SL @ 0.125 lit/ha, ethofenprox 10 EC @ 0.2 lit/ha were tried along with standard check, methyl demeton 25 EC @ 0.5 lit/ha and an untreated control. Two rounds of spraying were given at 57 and 72 days after sowing. Observations on jassid and aphid population (in three leaves *viz.,* top, middle and bottom in 10 plants selected at random leaving border rows) were recorded before and 7 and 14 days after each spraying. Yield data were also recorded. Results of the trial revealed that thiamethoxam at test doses was found to be *on par* with imidacloprid 200 SL and standard check. Maximum decrease of 73.8% jassid population was obtained in thiamethoxam 25 WG and imidacloprid 200 SL, followed by 72.1% and 68.8% in thiamethoxam 50 WG and standard check, respectively. Maximum decrease of aphid population was obtained in thiamethoxam 50 WG (93.8%), followed by imidacloprid 200 SL (89.2%) and thiamethoxam 25 WG (88.4%). Standard check recorded 84.8% decrease over untreated control. No phytotoxicity was observed with the chemicals tested. Thiamethoxam 25 WG @ 25 g ai/ha recorded seed cotton yield of 6.0 q/ha which was however *on par* with imidacloprid 125 ml/ha which recorded 6.2 q/ha.

5.28
Efficacy of chitin growth inhibitors on bollworms of cotton

G. B. BADADE, B. K. DHANORKAR, A. R. VIRKAR AND B. D. SHINDE
Department of Entomology, Marathwara Agricultural University, Parbhani-431 402

An experiment was conducted at the experimental field of Department of Entomology, Marathwada Agricultural University, Parbhani during *kharif* 1999-2000 to study the efficacy of chitin growth inhibitors against cotton bollworms. First spray was given at 5 per cent infestation of bollworms in fruiting bodies. Subsequent sprays were given at 15 days interval. All the insecticidal treatments were significantly superior over control in reducing bollworms infestation in fruiting bodies. The bollworms infestation was significantly low in (diflubenzuron+alphacyper) @ 300 g a. i./ha, followed by (diflubenzuron+alphacyper) @ 150 g a. i./ha, (diflubenzuron+alphacyper) @ 112.5 g a. i./ha and diflubenzuron+alphacyper) @ 93.5 g a. i./ha.

5.29
Molecular marker for genetic variation of whitefly (*Bemisia tabaci* Genn.)

SHEO RAJ, K. N. GUPTA, D. MONGA AND S. K. BANERJEE
Central Institute for Cotton Research, Nagpur-440 010

The protocol for isolation of DNA from whitefly was standardized. Random amplified polymorphic DNA (RAPD) analysis of whitefly DNA was carried out to study polymorphism in whitefly population. We tested 20 random primers of OPA Kit Operon tech., USA. Amplified product was analyzed on 1.0% agarose gel. The RAPD marker OPA-1, 2, 5, 9, 11, 13 and 16 were found to be useful for amplification of whitefly DNA. For subsequent numerical analysis of host associated genetic variation in whitefly population, reproducibility of RAPD-PCR result was verified by conducting replicated experiments. RAPD pattern of different population of whitefly from north India was considered for amplification. Though few band showed variation in relative DNA intensity, these primers amplified a range of template DNA fragment varying from base pairs. OPA-5 primer was good for amplifications and the number of amplified band were two to four and size obtained varied from 0.5 Kb to 2.0 Kb. On the basis of these results, the primer OPA-5 could be selected as primer for genetic variation of whitefly population.

5.30
Comparative efficacy of light and pheromone traps for cotton bollworms

P. JEYAKUMAR , M.C. JAT, AMAR SINGH, A.DHANDAPANI AND D. MONGA
Central Institute for Cotton Research, Regional Station, Sirsa- 125 055.

Trapping is one of the most important sampling techniques for insect survey. Traps can be either active or passive in their mode of collection. Active traps rely on a physical or a chemical stimulus to lure insects into them. The light trap is the most widely used visual trap (physical stimuli), however, the pheromone traps are operating through olfactory sensilla (chemical stimuli). Both these traps are widely used in monitoring and surveillance programmes of Lepidopteran pests.

An experiment was laid out in farmers field at Panjuana village in Sirsa district of Haryana to study the interaction effect of light and pheromone trap in catching adult moths of all the bollworms during cotton season 2002. In this experiment replicated trials consisting of light trap alone, light trap with pheromone trap (within 10 m radius) and pheromone trap alone installed in 10 acre field and observations were made at three days interval throughout the season. The light trap (26.40-30.60 and 84.68-99.95 adults/3 nights) catches were significantly better than pheromone trap (8.90-9.32 and 25.64-36.14 adults /3 nights) for *Helicoverpa armigera* and *Earias* spp., respectively. The trap catches between light trap with pheromone and light trap alone were not significantly different. Similarly pheromone traps with or without light were not significantly different with each other.

For pink bollworm, *Pectinophora gossypiella,* the light trap catches were zero while pheromone trap catches very low (0.95 adults /3 nights). It was conluded that the light traps were superior to pheromone traps for *H. armigera* and *Earias* spp. and catches by light trap were not influenced by pheromone traps when these were installed adjacently or *vica versa.*

5.31
Interaction effect of pheromone trap catches of cotton bollworms

P. JEYAKUMAR, M. C. JAT, A. DHANDAPANI, D. MONGA, A. J. TAMHANKAR, R. K. TANWAR AND O. M. BAMBAWALE

Central Institute for Cotton Research, Regional Station, Sirsa-125 055

Insect pests especially bollworms are the key factors for low cotton yields. Sex pheromone traps have been used for monitoring or mass trapping or for male confusion of bollworms adults by several workers. A study was carried out in farmers field at Rangri village, Sirsa disrict of Haryana throughout cotton season 2003-2004 to find out the feasibilityof instaling different types of traps on a single bamboo.
Three separate experiments with three pheromone traps at different heights *viz.,* for *Pechinophora. gossypiella* (PBW) at 15 cm, *Earias* spp. (SBW) at 45 cm and *Holicoverpa* (ABW) at 60 cm height above crops canopy were conducted. In each experiment four treatments consisting of main trap alone, main trap +trap no.2, main trap + trap no.3 and all three traps tied in same bamboo were replicated five times.
The results showed that there was no significant difference in catches (no. of adults / three nights) of the three bollworms traps, either singly or in combination with others. The ABW adults traps catches were more (11.8 adults /3 nights), when combined with SBW, than ABW alone (9.2). However, SBW trap alone trapped more number of adults (32.7) than in combination with other traps (23.2-26.8). This situation remained the same in PBW also, but unlike SBW, the difference between PBW alone (11.6) and in combination (10.5-11.3) was very narrow. From this study it came to light that the interference effects between different traps on each other is not significant, and to economise bamboo stick and manpower all the three traps could be placed on a single bamboo at different heights.

5.32
Field evaluation of cotton genotypes against leafhopper, *Amrasca biguttula biguttula (*Ishida*)*

P. RADHIKA, K. SUDHAKAR, S. BASHA MOHIDDIN, AND G. M. V. PRASADA RAO
Acharya N. G. Ranga Agricultural University, Regional Agricultural Reasearch Station, Nandyal-518 503

Seventy-four entries of *Gossypium hirsutum* obtained from All India Co-ordinated Cotton Improvement Project were field evaluated for their tolerance/resistance to the most important sap sucking insect i.e. *Amrasca biguttula* (Ishida) at the Regional Agricultural Research Station, Acharya N.G. Ranga Agricultural University, Nandyal during the year 1990-2000. Leafhopper injury grades was recorded for each entry using ICCC 1 - 4 scale when the susceptible check reached 4 scale. The enries were categorised based on injury index. The results revealed that one entry (CNH 120 MB) was resistant while 50 entries moderately resistant, 14 entries susceptible and nine entries highly susceptible.

5.33
Variegated presence of microflora on Asiatic cottons in south zone

P. R. VIJAYA KUMARI, R. K. DESHMUKH AND V. SANTHY
Central Institute for Cotton Research, Nagpur 440 010

Forty three (29 of *herbaceum* + 14 of *arboreum* species) seed samples of cotton were collected from three states *viz.,* Karnataka, Andhra Pradesh and Tamil Nadu (i. e. south zone) to analyze the presence of different fungi during 1991-'92 to 1997-'98. The seed samples were subjected to "Standard Blotter Method" (SBM) and observed after 7 days of incubation for the presence of fungi. It was observed that none of the seed samples were free from fungi and there were as many as 19 different genera of fungi present on these samples. Among

the years the fungal load was as low as 149 comprising 7 genera of field fungi on two cultivars in 1997-'98 seed samples whereas it was as high as 750 with 10 field fungi genera on five cultivars of 1991-'92 samples. The storage fungal load comprising *Aspergillus* and *Penicillium* was 49 on Arbhavimath samples in 1991-'92 and 487 in 1993-'94 samples of Seed Testing Laboratory (STL) Dharwad. The contaminant fungus i. e. *Rhizopus nigricans* was high in almost all the samples barring 1991-'92 samples where its presence was 22.60 per cent. The presence of fungi *viz.,* species of *Alternaria, Curvularia, Dresclera, Phoma, Macrophomina, Colletotrichum, Rhizoctonia, Pestalotipsis* and *Botryodiplodia* varied from 0.5 -5.0 per cent on the seed samples over these years. *Fusarium* spp was minimum (i. e. 1.64%) on STL-Dharwad samples in 1993-'94 and maximum (i. e 72.67%) on Arbhavimath samples in 1991-'92. Fungi like *Epicoccum* spp., *Cladosporium* spp., *Chaetomium* spp., presence was more than 10% in most of the samples. Barring *Chaetomium* spp., the seed samples from Arbhavimath (1994-'95), Kovilpatti (1994-'95) and Siruguppa (1995-'96) carried low load of field fungi i. e. 45, 12 and 31, respectively. Thus, the study revealed that the places can be demarked by the presence of different fungi and can be exploited for seed production purpose with non or less pathogens/diseases to add better value to the seed lot. It appeared that places like Arbhavimath, Kovilpatti and Siruguppa were less loaded with fungi which need to be confirmed through further study.

5.34
Integrated management of *Fusarium* wilt of cotton

C. R. KSHIRSAGAR, A. C. JADHAV AND N. B. PAWAR

Department of Plant Pathoglogy, (AICCIP) College of Agriculture, Pune-411 005

Fungicides and biocontrol agents were screened against *Fusarium oxsyporum* f. sp. *vasinfectum in vitro.* Effect of fungicides on biocontrol agents was also studied *in vitro.* Fungicides having no deleterious effects on biocontrol agents were used for integration. Fungicides, benomyl (0.1%), carbendazim (0.1%) and captan (0.2%) gave complete control of *Fusarium* wilt in pot culture experiment in 'sick soil'. Integration of captan (0.1%) + *Trichoderma harzianum* also gave total control of the disease. Captan (0.1%) + *Trichoderma viride* also showed good control of the disease i. e. 16.16 per cent disease incidence only.

5.35
Development and survival of *Earias vittella* (Fab.) on cotton during different months in Haryana

A. CECILY AND R. K. SAINI
Department of Entomology, CCS Haryana Agricultural University, Hisar-125 004

Field studies were conducted on the development and survival of *Earias vittella* (Fab.) (Lepidoptera: Noctuidae) by releasing different immature stages of the pest on cotton crop during July to October, 2001. Mean incubation period was 3.19 (2-5) days. Egg hatchability was 83.0, 74.9, 65.6 and 64.3 per cent during July, August, September and October, respectively and about 28 per cent eggs were inviable. Highest percentage (32.8) of eggs hatched after three days of oviposition. Mean larval duration was 10.15, 10.37 and 11.46 days during July, August and September, respectively while pupal duration was 10.06, 11.28 and 12.56 days during August, September and October, respectively. No significant differences in larval or pupal durations during different months were observed. Mean larval survival was 30, 25 and 30 per cent during August, September and October, respectively. After the release of first instar larvae on the crop, on an average 48 per cent larvae died within the first two days, 62 per cent within 5 days and upto 72 per cent before pupation. Rate of mortality declined with the increase in larval age.

5.36
Incidence of spotted bollworms (*Earias* spp.) in upland cotton during different months

A. CECILY, R. K. SAINI AND PALA RAM
Department of Entomology, CCS Haryana Agricultural University, Hisar-125 004

Weekly incidence of spotted bollworms [*Earias insulana* Boisd. and *Earias vittella* (Fab.)] was recorded on cotton during July to October, 2001 at the Research Farm of Department of Entomology, CCS Haryana Agricultural University, Hisar. During July, on an average 14.54 per cent plants and 3.63 per cent shoots were found damaged by the pests. The highest damage was observed during the 4th week wherein 20.6 and 5.1 per cent incidence was recorded on plant and shoot basis, respectively. The pests incidence in shed and intact fruiting bodies reached its maximum during the second weed of September, which was also significantly higher than incidence during the first fortnight of August. Damage to fruiting bodies was maximum in September (56.87%), followed by August (48.31%) and October (41.52%). Incidence in shoots exhibited negative correlation with temperature and positive correlation with relative humidity while in fruiting bodies it had positive correlation with temperature and no correlation with relative humidity. Nevertheless, the incidence starting from July continued to increase upto mid-September and declined thereafter. Mean larval intensitiy was 0.9 larva / 10 plants during July. On fruiting bodies (shed + intact) month wise mean larval intensity was 2.5, 2.2 and 0.9 larvae / 10 fruiting bodies during August, September and October, respectively. However, the highest intensity (2.3-3.3 larvae / 10 fruiting bodies) was recorded during the third week of August to second week of September.

5.37
PBO suppressible resistance in cotton aphid, *Aphis gossypii* Glover to selected insecticides in Andhra Pradesh

K. JHANSI AND G. V. SUBBARATNAM
Department of Entomology, Acharya N. G. Ranga Agricultural University, Rajendranagar, Hyderabad-500 030

Synergists play a unique role in the efficient, economical and safe use of insecticides. Insecticide synergists are potentially important pest management components because they may increase insecticidal activity against resistant arthropds. Studies were conducted on the occurrence of metabolic mediated resistance in cotton aphid, *Aphis gossyii* to selected insecticides *viz.,* endosulfan, monocrotophos, dimethoate, phosphamidon, carbaryl and cypermethrin using the synergist PBO in 1 : 10 and 1 : 5 ratio. The relatively resistant aphid population of Warnagal district exhibited PBO suppressible metabolic resistance of 2.54 for 1 : 5 ratio and 3.50 for 1 : 10 ratio to endosulfan. Monocrotophos was synergised by PBO to the tune of 3.33 fold for 1 : 5 ratio and 4.12 fold for 1 : 10 ratio at LC50. The synergistic factor due to mixing of dimethoate with PBO was 1.92 for 1 : 5 ratio and 2.40 for 1 : 10 ratio at LC_{50} to relatively resistant Warangal population of *A.gossypii.* Phosphamidon was synergised by PBO to the extent of 2.15 fod for 1 : 5 ratio and 4.94 fold for 1 : 10 ratio at LC_{50}. The synergistic factor due to mixing of PBO with carbaryl was 1.28 for 1 : 5 ratio and 1.88 for 1 : 10 ratio at LC_{50} in aphid population of Warangal distrcit. Cypermethrin in combination with PBO showed synergistic factor of 4.44 for 1 : 5 ratio and 6.67 for 1 : 10 ratio at LC50 in *A.gossypii* population of Warangal district.

5.38
Relative toxicity of selected insecticides to cotton aphid, *Aphis gossypii* Glover in Andhra Pradesh

K. JHANSI AND G. V. SUBBARATNAM
Department of Entomology, Acharya N. G. Ranga Agricultural University, Rajendranagar, Hyderabad-500 030

Cotton aphid, *Aphis gossypii* Glover is a polyphagous pest of many plant species. Indiscriminate use of several chemical insecticides to *A. gossypii* resulted in the development of resistance to insecticides. The toxicity of six insecticides *viz.,* endosulfan, monocrotophos, dimethoate, phosphamidon, carbaryl and cypermethrin was evaluated against *A. gossypii* of Warangal, Prakasam, Adilabad and Kurnool districts of Andhra Pradesh using leaf dip method. Relative toxicity of different insecticides was determined by taking the LC_{50}/LC_{90} values of endosulfan as unity for each district separately. Monocrotyphos was more toxic to the aphid population of Warangal district, followed by cypermethrin, carbaryl, dimethoate and phosphamidon at LC_{50} and at LC_{90}. In Prakasam district monocrotophos, cypermethrin, phosphamidon, dimethoate and carbaryl were more toxic at LC_{50} and at LC_{90} while phosphomidon and carbaryl were less toxic than endosulfan. In the case of Adilabad district monocrotophos, cypermethrin and phosphomidon were more toxic at LC_{50} while only monocrotophos was more toxic at LC_{90} than endosulfan. To the aphid population of Kurnool district monocrotophos, cypermethrin and phosphomidon were more toxic at LC_{50} and at LC_{90} only monocrotophos and cypermethrin were more toxic than endosulfan.

5.39
Cry 1 Ac toxin and its impact on resistance development in cotton bollworms

S. KRANTHI, K. R. KRANTHI, V. R. DHEPE, S. R. NAIDU AND S. N. NAWAZ
Central Institute for Cotton Research, Nagpur-440 010

With the introduction of *Bt* cotton in Indian agriculture, substantial changes are expected in the cotton pest scenario. Harbouring the Cry l Ac gene, *Bt* cotton released as Bollgard I forms the first generation transgenic that has been commercialized in India. This paper discusses the impact of Cry 1Ac on the cotton bollworms, with special emphasis on the spotted bollworm, *Earias vittella* (Fab.). An insight is provided on the baseline susceptibility of *Earias* sp and *Helicoverpa armigera* to Cry 1Ac that was measured for over three years using a diet based bioassay method. *Earias* sp was successfully reared on semi-synthetic diet for at least eleven generations in the laboratory. We, at CICR, elaborately studied the frequency of resistance alleles and its estimation and the probable mechanisms mediating resistance in *E. vittella* and *H. armigera.*

5.40
Epidemiological studies on bacterial blight of cotton

RAKESH CHUGH, ANIL GUPTA, MANOJ KUMAR AND J. K. DANG
Department of Plant Pathology, CCS Haryana Agricultural University, Hisar-125 004

Bacterial blight of cotton (*Xanthomonas axonopodis* pv. *malvacearum*) is a serious disease and causes enormous losses. To study the survival of the pathogen, cotton leaves (showing typical symptoms of blight) and seeds of diseased plants were collected and stored in paper bags at room temperature in October 2001. Regular monthly observations were taken for the presence of bacterium by dilution streak method. Studies were also conducted to determine the relationship of bacterial blight with weather variables during two consecutive crop seasons of 2002 and 2003 to develop functional disease weather relationship system. Susceptible cv. HS-6 was sown on different dates during both the years and all the recommended agronomical practices were followed for raising the crop.

The results showed that the pathogen was viable both in stored leaves and seeds up to March 2004. Further regular observations are being taken on the presence and viability of the pathogen. First symptom of the disease appeared in the first week of June 2002 and third week of July 2003. Cumulative maximum disease intensity was 24.13 and 36.0 per cent (in the last week of August during both the years) at maximum temperature range of 32-36°C and minimum 25-27°C, respectively with relative humidity more than 80 per cent. The temporal progress of the disease started declining after August. Correlation coefficient was significant with relative humidity and temperature. Using stepwise regression analysis, the variability could be explained between 58 and 60 per cent with temperature as one of the determinators. Studies are in progress to validate the hypothesis.

5.41
Relationship of micro climatic parameters with population dynamics of leafhopper and whitefly in cotton

SEWA SINGH, RAM NIWAS, R. K. SAINI AND M. L. KHICHAR
Department of Agricultural Meteorology, CCS Haryana Agricultural University, Hisar-125 004

Studies on the effect of microclimatic parameters *viz.* temperature, relative humidity and vapour pressure deficit on population dynamics of leafhopper, *Amrasca biguttula* (Ishida) and whitefly, *Bemisia tabaci* Genn., in cotton were conducted during *kharif* 2001 at the Research Farm of Department of Entomology, CCS Haryana Agricultural University, Hisar. For this purpose cotton variety HS-6 was sown on May 20, 2001 keeping a row to row and plant to plant distance of 60 and 30 cm, respectively. Observations on microclimatic parameters and pests' population were recorded at weekly interval starting from 40 days after sowing of crop. The population counts were made at three canopy levels i. e. lower, middle and upper and at three times of the day i. e. at 8.00 a. m., 12.00 noon and 5.00 p. m. The results indicated that the optimum ranges of the above parameters for leafhopper population build-up were 32-34°C temperature, 81-92 per cent relative humidity and 1-6 mm of Hg vapour pressure deficit. The corresponding optimum ranges of microclimatic parameters for whitefly were 25-29°C, 68-75 per cent and 5-10 mm of Hg, respectively. Leafhopper population was maximum in the upper canopy and in the morning hours, while whitefly population was more in the lower canopy and did not differ much at different times of the day. It was suggested that sampling for leafhopper may be preferred in the upper canopy and during morning hours white it may be observed from lower canopy and at any time of the day for whitefly. Leafhopper population was positively correlated with temperature (r=0.70) and relative humidity (r=0.83) and negatively correlated with vapour pressure deficit (r=-0.73), indicating highest correlation of the population with relative humidity as compared to other parameters. Similarly, whitefly population was negatively correlated with temperature (r=-0.94) and vapur pressure deficit (r=-0.97) and positively correlated with relative humidity (r=0.93), indicating highest correlation of the population with vapour pressure deficit in comparison to other parameters. The regression model based on micro-climatic parameters explained the variability in leafhopper population upto 77 per cent ($Y=-6.246 + 0.12X_1 + 0.039X_2 +0.027X_3$) and in whitefly upto 98 per cent ($Y=23.69-1333X_1+0.51X_2+1.12X_3$).

5.42
Efficacy and standardization of dose of readymix formulation 'Ustad Gold' against insect pest complex infesting cotton and its impact on potent predators

S. B. DAS AND O. P. VEDA
Zonal Agricultural Research Station, Jawaharlal Nehru Krishi Vishwa Vidhalaya, Agricultural University, Khargone-451 001

Efficacy of ready mix formulation Ustad Gold (19.5% WP) (imidacloprid + cypermethrin) at four different doses *viz.* 200, 300, 400 and 500 g/ha and single dose of their individual counterparts, imidacloprid 17.8SL (112 ml/ha) and cypermethrin 25EC (240 g/ha) was evaluated against sucking pest complex *viz.* jassid,

Amrasca biguttula biguttula Ishida (Hemiptera: Cicadellidae); thrips, *Thrips tabaci* Lind. (Thysanoptera: Thripidae) and whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) and bollworms infesting cotton. Their impact on potent predators - lady bird beetles, *Coccinella* sp. (Coleoptera : Coccinellidae) and green lacewings, *Chrysoperla carnea* (Neuroptera : Chrysopidae) was also observed. The trial was conducted at Zonal Agricultural Research Station, J. N. Agricultural University, Khargone (M. P.) during 2001-2003.
The results revealed that all the doses of ready mix insecticide formulation significantly reduced the pest complex infestation, both over control and individual counterparts and also registered higher seed cotton yield. Ustad Gold (19.5% WP) @ 400 g/ha was found to be highly effective in minimizing the sucking pest complex infestation and also recorded minimum boll damage with maximum seed cotton yield. Its higher dose *i. e.* 500 g/ha was *on par* with its lower dose (400 g/ha). All the doses of Ustad Gold (19.5% SP) included in the study and their individual counterparts did not exhibit any phytotoxicity to the cotton crop. Furthermore, they did not have any deterimental effect on the common predators and were found to be quite safe.

5.43
Current status of stem weevil, *Pempherulus affinis* Fst., in summer rice fallows of southern Tamil Nadu

P. CHANDRAMANI, N. MURUGESAN, N. SIVASAMY AND P. AMALA BALU
Cotton Research Station, Tamil Nadu Agricultural University, Srivilliputtur-626 125

At Cotton Research Station, Srivilliputtur, the infestation of stem weevil on cotton was seen throughout the year 2003. The incidence was higher during August- September (June sown crop) and December -January (August sown crop) and lesser in May-June (February sown crop). In the cultivar SVPR 3, 100 per cent incidence with 78 per cent mortality of plants was observed in June sown crop, while the incidence was 65 and 82 per cent with mortality of 8 and 86 per cent in February and August sown crop, respectively. Application of neem cake 150 kg/ha + neem oil 1 per cent drenching and earthing up 25 DAS was found to minimize the stem weevil incidence and CB ratio of 1:3.45 was realized in this treatment.

5.44
Incidence and management of root-knot nematode (*Meloidogyne incognita*) infecting cotton (*Gossypium hirsutum*)

R. K. JAIN
Department of Nematology, CCS Haryana Agricultural University-125 004

Root-knot nematode (*Meloidogyne incognita*) is one of the major nematode pests affecting cotton. Its incidence in major cotton growing areas of Haryana (i.e. Hisar and Sirsa) has earlier been recorded with avodidable loss in yields to the extent of 19.9 per cent. Present study was undertaken to record its incidence and attempt its management in another cotton growing area (Distt. Bhiwani). The soil and root samples from cotton fields from different locations in Bhiwani District were collected during *kharif* 2002. Out of 38 cultivation units, eleven exhibited infestations of root-knot nematode, thus showing 28.9 per cent frequency of occurrence. Maximum frequency (40.0 per cent) with root-knot index ranging from 3-4 was in Loharu. For management of *M. incognita* under field conditions, seed treatment alone and in combination with soil application of different nematicides was evaluated. There were ten treatments, each replicated three times in a randomized block design. The initial nematode population ranged between 192 J_2/200 g soil to 205 J_2/200g soil. Cartap hydrochloride used as seed dressing treatment adversely affected seed germination. The maximum yield (11.0 q/ha) with 19.6 per cent increase over untreated control was recorded in carbosulfan seed soaking treatment @ 500 ppm + soil application with carbofuran @ 1.0 kg a. i./ha (T_3), followed by 109 q/ha (18.5 per cent increase in carbosulfan seed treatment @ 3.0 per cent a.i. (w/w) + soil application with carbofuran @ 1.0 kg a i/ha (T_4) in comparison to 9.2 q/ha in untreated check (T_1). Treatments involving seed treatment with cartap hydrochloride had 2.6 and 2.4 q yield/ha in T_7 and T_5 respectively. Root-knot index at harvest was maximum (4.4) in T_1 (untreated control) while it was minimum (2.5) in T_4.

5.45
Sources of resistance to Alternaria blight (*Alternaria macrospora* Zimm.) and grey mildew (*Ramularia areola* Atk.) in *desi* cottons

S. V. HIREMATH, V. B. NARGUND, S. N. CHATTANNAVAR AND B. M. KHADI
Department of Plant Pathology, College of Agriculture, Bheemarayanagudi-585 287

Cotton is one of the important cash crops and a major source of raw material for fabric sector. Alternaria blight caused by *Altenaria macrospora Zimm.* and grey mildew (*Ramularia areola* Atk.) are the two major diseases of *desi* cottons. Development of resistant varieties/hybrids apparently offers most economical means of controlling the diseases. With this objective, 65 cotton genotypes from *Gossypium herbaceaum* and *G. arboreum* along with susceptible checks were screened during 2000-03 against Alternaria blight and grey mildew under field conditions at Agricultural Research Station, Dharwad. All the genotypes were artificically inoculated twice with *Alternaria* and *Ramularia* cultures apart from providing local susceptible check after every two test rows. Disease scoring was done 140 days after sowing. The results indicated that genotypes PAIG-127, JLA-794, CAD-127, MOL-2502, LD-807, RASI, KWA-23, PA-405, DLSA-17, CINA-305, GAM-69, FMDH-222, DDhc-20 and DDAC-22 exhibited immune reaction to Alternaria blight, while the genotypes NDLA-2463, CISV-270, HD-224, KWA-135, DLSA-17, AKDH-3, JRFD-5, MRCD-226, GSGDH-7, AAH-15, NACH-7, GK-132, KR-32, RAHS-101, DDhc-20 GBhv-222 and DDhc-20 showed immune reaction to grey mildew. The genotypes PAIG-127, JLA-794, GMA-107, NA-529, KWA-23, PA-405, DLSA-17, CINA-305, GAM-69, MDH-999, CISA-43, FMDH-3, GBhv-222, and DDhc-20 exhibited multiple resistance possessing immune reaction to both alternaria blight and grey mildew. Thus, the genotypes PAIG-127, DDhc-20, DLSA-17, NA-529, PA-405, CINA-3 and GAM-69 exhibiting multiple resistance and GAM-69 can play vital role in reducing disease incidence.

5.46
Role of nematodes in biological control of cotton insect-pests

NANDINI GOKTE-NARKHEDKAR, N. V. LAVHE, S. K. BANERJEE AND SHEO RAJ
Central Institute for Cotton Research, Nagpur- 440 010

The entomopathogenic nematodes (EPN) have generated a great deal of interest in recent years because of their reconginition as bio-control component in integrated pest management (IPM) of cotton. The insect-pests attacking nameatodes have found a great utility in IPM system because of their locomotory ability causing a quick death of the insect pests. Entomopathogenic nematodes belonging *Heterorahabditis indicus* isolated from cotton ecosystems (rainfed, irrigated) were evaluated against American bollworm (*Helicoverpa armigera*) and other cotton insect pests. *H. indicus* was found effective against *Spodoptera litura,* leaf roller (*Sylepta derogata*), pink bollworm (*Pectinophora gossypiella*) and spotted bollworm (*Earias spp.*) with significant insect larval mortality. Ten infective juveniles (IJ) of *H. indicus* per larva of *H. armigera* was found to be effective dose. The spray schedule of *H. indicus* infective juveniles has been worked out in delivery system of cottom IPM. Field application of *H. indicus* at 1 billion/m^2 was found to reduce the American bollworm population by 58 per cent. The field results indicated that use of entomopathogenic nematodes had great potential in the management of cotton insect-pests, particularly the American bollworm causing heavy field losses and damaging environment due to use of harmful pesticides.

5.47
Role of inundative releases of *Trichogramma chilonis* Ishii in reducing bollworms incidence in cotton

PALA RAM, OMBIR AND B. S. CHHILLAR
Department of Entomology, CCS Haryana Agricultural University , Hisar 125 004

Inundative releases of *Trichogramma chilonis* Ishii were evaluated against bollworm complex in cotton (var. H 1117) in larger plots (800 m^2). Nine inundative releases of the rate of 1.5 lacs per hectare were made from July to September, 2003. Honey fed adults of the parasitoid were released in the morning hours. Eggs of *Helicoverpa armigera* (Hubner) were collected frequently to record egg parasitism. Eggs of pink bollworms and spotted bollworms were not observed for egg parasitism. Opened cotton bolls were collected to record boll damage due to bollworms. Egg parasitism of *H. armigera* ranged from 15.4 to 32.5 per cent (average 25.2 per cent) in released plot whereas it ranged from 5.0 to 18.5 per cent (average 11.4 per cent) in control plot. Boll damage was 12.2 per cent in released plot and 21.9 per cent in control plot. On locule basis, the boll damage was 6.0 per cent in released plot and 10.4 per cent in control plot.

5.48
Assessment of crop losses due to cotton leaf curl virus (CLCuV) disease

J. P. S. YADAV, P. P. JAIN, K. S. NIRANIA, M. S. BHATTOO AND YAGYA DUTT
CCS Haryana Agricultural University, Cotton Research Station, Sirsa-125 055

Cotton leaf curl virus (CLCuV) has become the most important disease problem in northern cotton growing zone of the country. The disease was first noticed at Abubshahar (Haryana) in 1994. The disease has appeared in serious form in almost all cultivars of *Gossypium hirsutum*. An experiment was conducted during *kharif* 2001 and 2002 on variety HS-6 grown in 150 m^2 area. All recommended package of practices were followed. Diseased plants were tagged at 15 days interval and were scored 0 to 4 grade of disease for estimation of losses. The results indicated that there was 10.72-45.66 and 12.4-80.6 per cent reduction in seed cotton yield during 2001 and 2002, respectively.

5.49
Studies on cotton leaf curl virus disease in relation to weather factors

J. P. S. YADAV, P. P. JAIN, K. S. NIRANIA, M. S. BHATTOO AND YAGYA DUTT
CCS Haryana Agricultural University, Cotton Research Station, Sirsa-125 055

Insect-pest and diseases are the important factors causing reduction in yield of cotton. Cotton leaf curl virus (CLCuV) is one of the major factors responsible for decline in area of American cotton in Haryana. The incidence of disease varied from traces to 80 per cent during the crop season. Observation on first appearance of the disease on variety HS-6 and weather data were recorded. The first disease incidence was recorded on 20.5.2001. The maximum increase in disease development was observed in the months of July and August. The progress of disease was slow from the last week of August to September. No progress of disease was noted after 25th September 2001. The population of whitefly ranged between 0.23 and 1.2/leaf starting from the month of June to September. The average maximum temperature in June-July was 35°C and maximum RH was 82 per cent. Sun shine hours ranged from 5.2 to 7.4 and the maximum disease recorded was 80 per cent.

5.50
Situation of cotton diseases in Fatehabad district of Haryana

KISHOR CHAND KUMHAR, KISHAN LAL JAT, S. N. NANDAL, M. S. CHAUHAN, P. D. SHARMA AND S. S. KHARUB
CCS Haryana Agricultural University, Krishi Vigyan Kendra, Fatehabad-125 050

Cotton is the most important fibre and cash crop of north India. In Haryana, cotton (both *desi* and American) is mainly grown in Hisar, Fatehabad and Sirsa districts. Cotton production and quality is affected by various factors such as climate, seed quality, sowing time, attack of insect-pests and diseases. Cotton is affected by a number of diseases. Under NATP project operating at KVK, Fatehabad in village Hizrawan Kalan, Dhani Dhaka, Dhani Chhatrian, Dhani Issar and Daulatpur, surveys were conducted in 2001, 2002 and 2003 to find out the occurrence of various diseases like seed rot, seedling disease, wilt, CLCuV, *Myrothercium* leaf spot, *Alternaria* leaf spot, angular leaf sopt and boll-rotting. To record disease incidence two groups of farmers were made i. e. IPM farmers and non-IPM farmers. Each group had twenty farmers and occurrence of diseases was recorded at weekly interval. Disease incidence was high in non IPM faermers than the IPM farmers. This was because of the fact that the non-IPM farmers followed sowing of local varieties, improper time of sowing and injudicious use of pesticides, etc.

5.51
Predominance of *Rhizoctonia* species causing root rot of cotton in Haryana

S. S. JAKHAR, M. S. CHAUHAN, J. C. DUHAN AND ANIL AHLAWAT
Department of Seed Science & Technology, CCS Haryana Agricultural University, Hisar-125 004

The investigations on root rot of cotton in *Gossypium hirsutum* L., *G. arboreum* and *intra-hirsutum* hybrid were conducted. In total, 140 samples of 12 varieties and two hybrids were collected during 1995 and 1996 respectively. The study showed that *Rhizoctonia solani* Kühan, *R bataticola* (Taub.) Butler and *Macrophomina phaseolina* Tassi. Goid were found dominantly in all the cotton growing districts of Haryana *viz.* Hisar, Sirsa, Bhiwani, Mahendragarh, Jind, Rewari, Rohtak and Kaithal through out the crop season during 1995 and 1996. During 1995, *Rhizoctonia bataticola* was found dominating over *R. solani* from May to June, whereas *R. solani* was found dominating over *R. bataticola* from July to October. Similarly during 1996, *R. bataticola* was dominating over *R. solani* from April to May, while in June more than 50 per cent plants showed predominance of *R. solani* over *R. bataticola.* During July to August 1996, *R. solani* dominated over *R. bataticola. G. arboreum* was found more affected, followed by *G. hirsutum* and *intra-hirsutum* hybrids.

5.52
Bio-efficacy of new insecticides against cotton bollworms in field conditions

B. B. BHOSLE, K. S. RATHOD, N. R. PATANGE AND A. W. MORE
Marathwada Agricultural University, Cotton Research, Station, Nanded-431 602

Cotton is one of the most important commercial crops playing a key role in the economy of our country. *Helicoverpa armigera* and other bollworms seriously infest cotton in Maharashtra and other states of India. The application of different insecticides has given significant control of cotton bollworms but their injudicious use has resulted in the development of resistance to several of these insecticides. In view of the introduction of new molecules, the present studies were aimed at to study their comparative efficacy against bollworms, especially in rainfed conditions of Nanded. In addition, this study was aimed at to provide option for negative resistance management which may also find place as tool for effective measure in hot spot areas.

The results indicated that against bollworms spinosad @ 2.5 EC and combination of CHP+spinosad @ 625+31.25 g a.i./ha were comparatively better spray option as compared to chlorpyriphos, Spark and Polytrin-C. These treatments also resulted in relatively higher yield of seed cotton. Highest seed cotton yield was

recorded in treatment spinosad 2.5 EC @ 25 g a.i./ha (945 kg/ha) and it was *on par* with CHP+spinosad @ 625+31.25 g a.i./ha (817 kg/ha). Rest of the chemical treatments were significantly superior over untreated control, but *on par* with each other. Above tested molecules could be effectively used to break the cycle of resistance if sprayed on alternate basis.

5.53
Evaluation of cotton germplasm (*Gossyium hirsutum* L.) against emerging disease problem of cotton leaf curl virus in Haryana

JAGDISH BENIWAL AND J. P. S. YADAV
Department of Plant Breeding (Cotton Section), CCS Harayana Agricultural University, Hisar-125 004

Cotton leaf curl virus disease caused by Gemini virus and transmitted by whitefly is a major and destructive disease prevalent throughout cotton growing area of north India. In India, the disease was recorded in 1989 on collections of *Gossypium barbadense.* In 1993, the disease was first observed on *G. hirsutum* varieties near Sriganganagar in Rajasthan and subsequently during *kharif,* 1994 in Sirsa district. The cotton leaf curl virus disease is capable of causing 10 to 75 per cent losses in yield of seed cotton. The disease can be managed by various methods like eradication or clean cultivation in and around cotton field, management of whitefly (vector) from early stage and development of resistant varieties/hybrids. The knowledge of source of resistance is must to carry out systematic breeding programme to incorporate effective resistant gene in promising genotypes. Two hundred seventy one germplasm lines of American cotton and their hybrids were tested under natural epiphytotic conditions. All germplasm lines were sown during *kharif* season of 2003-04 in randomized block design with four replication with a spacing of 67.5 x 30.0 cm. A susceptible variety HS-6 was sown as infector row after every two test entries so that uniform inoculum was available to all germplasm lines. Out of 271 genotypes screened, 180 were resistant, 53 moderately resistant, 33 moderately susceptible whereas, one genotype was found to be susceptible against cotton leaf curl virus.

5.54
Evaluation of insecticides for the control of tobacco caterpillar, *Spodoptera litura* infesting cotton

A. S. SOHI, K. S. BRAR, A. K. DHAWAN, A. K. ARORA, ANAND ANEJA, H. S. BHULLAR AND SUDHENDU SHARMA
Department of Entomology, Punjab Agricultural University,Ludhiana-141 004

The tobacco caterpillar is not a regular and serious pest of cotton. However, the damage to cotton crop in cotton belt of Punjab is on increase. During 2002 crop season, it caused economic damage in some pockets in Mansa, Faridkot and Abohar cotton belt of the state. Many insecticides recommended for management of bollworm complex during flowering period did not manage these pests at farmers' field. Keeping this in view 11 insecticides of six different groups recommended for bollworm control were evaluated in three different field *cum* laboratory trials against third instar larvae. Quinalphos @ 500 g, chlorpyriphos @ 1000g, acephate @ 1500g and endosulphan @ 875 g ai/ha were significantly better than spinosad @ 50, indoxacarb @ 75 g ai/ha and cypermethrin , fenvalerate both @ 50 and deltamethrin @ 10 g ai/ha. Quinalphos, chlorpyriphos, acephate and endosulphan re-evaluated in two sets of experiments confirmed their effectiveness against *S.litura*. In both the experiments, the mortality was 100 per cent in chlorpyriphos and endosulphan against 87-100 in quinalphos and 80 per cent in acephate. These four insecticides can be used for the management of *S.litura* along with bollworm complex on cotton. Among these, acephate and chlorpyriphos may be preferred for control of grown up caterpillar of American bollworm (*Helicoverpa armigera*) along with *S.litura*. Endosulphan and quinalphos can be used for the control of young caterpillar of American bollworm along with *S.litura*. Among these, endosulphan should be preferred in early flowering phase for management of *S.litura*. This will also provide control of spotted bollworm (*Earias* spp.) and early instars of American bollworm.

5.55
Row skipping at sowing for effective insecticidal dispersal against bollworms in cotton

JAI SINGH AND A.K. DHAWAN
Department of Plant Breeding, Punjab Agricultural University, Ludhiana-141 004

Generally cotton crop in high fertility soil becomes luxuriant at fruiting phase and it becomes difficult to penetrate into the field for spray against bollworms with manually operated sprayer even by making pathways through pressing branches. As a result the spray material is not properly dispersed in the central rows. The uncovered plants bear a few pickable bolls. Such plants contribute less towards final yield and greatly help the pests by acting as reservoirs. Keeping this problem in view experiments were planned on *desi* cotton variety LD 327 to skip a row after some rows at sowing to provide a path for spray operator. The four row skipping treatments done at 4^{th}, 5^{th}, 6^{th}, 7^{th} rows were compared will no skipping. Eight trials conducted over three years involving skipping of every 5^{th} row at sowing proved significantly better than no skipping as well as skipping of 6^{th} and 7^{th} row. Skipping of 5^{th} row not only lowered bollworms incidence on boll as well as loculi basis but also gave 22 per cent higher yield over no skipping treatment. In further four trials, spray interval of 15 days (4 sprays) in 5^{th} row skipping plots proved as effective as 6 sprays at 10 day interval. Thus, this can result in saving of two sprays. Low bollworms incidence and increased yield with row skipping may be attributed to uniform and efficient dispersal of pesticides.

EXTENSION MARKETING & DEVELOPMENT

6.1
Large scale demonstration of cotton integrated pest management in the Upper Krishna Project Command Area of Karnataka

A. G. SREENIVAS, G. N. KULKARNI AND V. B. NARGUND
University of Agricultural Sciences, College of Agriculture, Bheemarayanagudi-585 287

Large scale demonstration of integration pest management (IPM) of cotton under irrigated situation was undertaken during 2000-01 and 2001-02 in 10 villages of Shahapur *taluka* in the Upper Krishna Project Command area. Results revealed that the population of leafhopper, per cent bollworm damage and number of *Helicovepa armigera* eggs/plant were slightly more in the IPM blocks as compared to farmers practice (non-IPM) wherein 12-15 sprays with insecticides were made resulting in increased cost of plant protection. The number of predators (spiders and *Chrysoperla*) and number of good opened bolls/plant were higher in the IPM block. The cotton yield was significantly higher (20.0 to 30.75 q/ha) as compared to farmers practice (15.0 to 22.50 q/ha). Further, in the subsequent seasons survey was made to assess the impact of technology by which the outcome was very poor. Among the several components used in the IPM demonstration the neem formulations (both NSKE and commercial formulations) found first place accounting to 10-15% usage and HaNPV by 5% of the farmers. The farmers were very well convinced about the technology and with this per cent increase in yield in IPM block ranged from 17.64 to 33.33%.

6.2
Impact of insecticide resistance management strategies in cotton in Parbhani district

D. S. SURYAWANSHI, P. D. MANE AND D. G. MORE
Department of Entomology, Marathwada Agricultural University, Prabhani-431 402

Studies were undertaken on the impact of insecticide resistance management strategies in cotton in Prabhani district on the fields of 200 farmers in 15 villages during the year 2003-04. The treatments comprised of 1) IRM strategy and 2) Farmers' practice (non IRM). IRM strategy comprised of cultivation of sucking pest tolerant cultivars, seed treatment with imidacloprid 70 WS @ 7 g a.i./kg seed, zero insecticidal spray till 60 days (endosulfan 35 EC as 0.06 per cent spray in emergency), NSKE 5 per cent and endosulfan 35 EC as 0.06 per cent spray, HaNPV 250 LE/ha between 60-90 days, endosulfan not beyond 90 days, organophosphates (quinalphos 0.05/chlorpyriphos 0.05/profenophos 0.05 per cent) during 90-120 days and cypermethrin 25 EC 0.0075 per cent after 120 days. All the insecticidal sprays were applied on the basis of economic thrashold. The mean pest incidence in IRM plots was aphid 12.37/leaf, jassid-1.28/leaf, thrips-5.36/leaf, whitefly-0.87/leaf, per cent bollworms damage in fruiting bodies 8.94, whereas it was significantly more in non-IRM plots (aphid-19.42/leaf, jassid-2.0/leaf, thrips-12.34/leaf, whitefly-1.12/leaf and per cent bollworms damage in fruiting bodies-14.85). The population of natural enemies in IRM plots was significantly more (coccinellids-2.27/plant and chrysopids-1.16/plant) as compared to non-IRM plots (1.48 and 0.84/plant, respectively). Laboratory studies to monitor the insecticidal resistance with discrininating doses revealed that the resistance was highest to fenvalerate with mortality 42.49 per cent, followed by cypermethrin (51.88%), quinalphos (52.27%), methomyl (56.10%), endosulfan (57.44%) and spinosad (97.77%). The yield of seed cotton was 10.3 q/ha in IRM plots as compared to 7.65 in farmers' practice. There was 22.96 per cent reduction in insecticide sprays and the reduction in plant protection cost was to the tune of Rs. 1000/ha in IRM plots as compared to farmers' practice indicating that the IRM strategy was found to be much effective and economical.

6.3
Management of resistance in cotton bollworms and its economics over conventional pest management

A. K. WADKUTE, P. R. ZANWAR AND R. B. SHINDE
Department of Entomology, Marathwada Agricultural University, Parbhani-431 402

Strategy developed by CICR Nagpur under the project on Insecticide Resistance Management on cotton was implemented during 2002-2003 by Department of Entomology in 30 villages of Parbhani, Hingoli, and Amravati districts. The strategy was simple to adopt, ETL based, conserved the natural population of beneficial insects. Although, yield of cotton under IRM did not increase over conventional pest management but net profit of cotton grower was significantly higher in IRM than conventional pest management due to reduction in spray cost.

6.4
A crop model for optimum crop production and policy planning

S. S. MATHAUDA, R. K. MAHEY, ANUPAM SINGH, MANINDER SIGNH, RAMINDER KAUR, NAVNEET AGGARWAL AND S. S. MAHAL
Department of Agronomy & Agrometeorology, Punjab Agricultural Univerisity, Ludhiana-141 004

The field trial on the most popular cotton variety (LH 1556) was conducted at Research Farm, Regional Station, Faridkot to validate the COTTAM model on loamy sand soil under assured irrigation and recommended nutrients supply conditions. The 12 treatment combinations of dates of sowing x plant to plant spacing were replicated thrice in split plot design by keeping four dates of sowing (15th March, 5th April, 25th April and 5th May) in main plots and three plant to spacings (30, 45 and 60 cm) in subplots by keeping row to row spacing 67.5 cm. The depth of seed placement was 5 cm. Under all the treatments the model overstimated the source size (maximum LAI), which ranged from +17 to 47 per cent over the field observed LAI. The model underestimated the sink strength depicted through the number of open bolls/plant (ranging from 70 to 99 per cent of the actual). However, under 15th May sowing with 30 cm plant spacing the model overestimated open bolls/plant and maximum boll size. Under all the treatments the model-predicted seed cotton yield was underestimated which fell within 68 to 97% of the actual one, except for 15th May sowing with 30 cm plant spacing, where it was over estimated by 22%. Thus the COTTAM model may be used safely to predict seed cotton yield under 15th March, 5th April, 25th April (with plant spacing of 30 cm) and for 15th May sowings (at plant spacing of 45 cm) where the model-predicted seed cotton yield fell within 88 to 97% of the actual yield. This model may help the decision markers in policy planning on cotton.

6.5
Transfer of technology through front line demonstration in cotton

M. J. PAVASIA, U. G. PATEL AND K. B. SANKAT
Gujarat Agricultural University, Main Cotton Research Station,Surat 395 007

The Front Line Demonstration (FLD) is the recent approach towards the Transfer of Technology Programme for disseminating the latest agricultural technologies developed by the scientists on new crop varieties/hybrids, intergrated pest management, nutrient management and other crop management practices. This gives the best opportunity to the scientists to have effective linkage with the extension personnel and progrossive farmers and to have the vital feed back. During 2001-2002 a total of 99 FLDs were conducted by Gujarat Agricultural University, Surat in irrigated and rainfed conditions in four cotton growing zones of Gujarat. Among these, 86 were harvested successfully. Sixty two varietal demonstrations were laid out on new genotypes : 24 on G. Cot. 23, 29 on G. Cot. 21, six on G. Cot. 18 and three on G. Cot. 19 with recommended package of practices. On an

average 42.75, 32.30, 28.77 and 23.33 per cent increased seed cotton yield was observed, respectively against farmers practices with local/old variaties. Five demonstrations on IPM and 15 on agronomical trials (split application of N without P_2O_5) were laid out. An average increase of 33.57 and 18.12 per cent in yield with reduced cost and better quality cotton was obatined from IPM and agronomical FLDs, respectively as compared to yield obtained from farmers practices. Front Line Demonstrations have thus created real impact amongst the farmers of FLDs villages and neighbouring villages.

6.6
Adoption of IPM by cotton growers of Sirsa district

K. L. CHHABRA* AND BEENA YADAV**
CCS Haryana Agricultural University, Cotton Research Station, Sirsa-125 055

Indiscriminate use of chemical pesticides in cotton crop is a matter of serious concern because it has not only threatened the environment but has been the cause of eclogical imbalance. Integrated pest management is the need of the hour to tackle this problem. Keeping above facts in view, the present study was conducted in Sirsa district of Haryana covering randomly selected 100 cotton growers. It was found that 43 percent farmers were aware of the term IPM, whereas 32 per cent were those who actually adopted the practice. Majority of the faermers came to know about IPM during the last six years through Department of Agriculture. As far as adoption of various IPM practices was concerned it was observed that use of tolerant/resistant variety was adopted by maximum number of farmers, followed by cultivation practices and plant based material, mechanical methods, biological agents and environment compatible pesticides. The percentage of farmers adopting IPM related practices got declined during last five years. Thus, the fermers are required to be reinforced and motivated from time to time through various extension methods by various agencies/departments so that the adoption rate of IPM could be accelerated.

6.7
Economic viability of different interventions in cotton and cotton based cropping systems on farmers field under rainfed conditions

A. N. GIRI AND P. S. KAPSE
Cotton Research Scheme, Marathwada Agricultural University, Parbhani-431 402

Experiments were conducted on evaluation of cotton production technologies for economics viability at village Takli (Kumbhakarna), Dharmapuri in Parbhani distict and village Aral in Hingoli districts of Maharashtra during *kharif* 2003-2004 on 88 farmer's field each with 0.40 ha area. In all nine interventions were tested. Results indicated that growing of cotton on heavy soils enchanced average net returns by Rs. 5851/ha with input-output ratio of 2.30 as compared to shallow soils, whereas on well drained soils there was an average increase of Rs. 6503/ha in net returns with input-output ratio of 2.22 than ill drained soils. Growing of recommended hybrid PHH-316 (i.e. Ganga) and variety PH-348 (i.e Yamuna) recorded an additional average net returns of Rs. 3056/ha and Rs. 4124/ha with input-output ratio of 2.08 and 2.40, respectively over non-recommended hybrids. Growing of *Bt* hybrid cotton MECH-12 gave Rs. 2932/ha as additional net returns with input-output ratio 1.81 as compared to its non-*Bt* hybrid. In the case of cotton based intercropping systems, cotton + blackgram and cotton+pigeonpea noted an average increase in net returns by Rs. 4270/ha and Rs. 3326/ha, respectively with input-output ratio of 2.53 over farmer's practice of growing sole cotton. Dry seeding of cotton enhanced an average net returns by Rs. 4226/ha with input-output ratio of 2.49 as compared to onset of monsoon sowing whereas sowing of cotton immediately after onset of monsoon recorded an additional net returns of Rs. 4062 /ha with input-output ratio of 2.53 as compared to 7 days late sowing. Regarding plant population, recommended plant population (18518 plants/ha) of American hybrid NHH-44 resulted in enhancing average net returns by Rs. 2421/ha with 2.43 input-output ratio over farmer's practice of sowing of cotton at wider spacing. Similarly recommended plant population (55555 plants/ha) of American

variety PH-348 and 95765 plants/ha of *desi* cotton PA-255 noted an average increase in net returns by Rs. 2755/ha and Rs. 1873/ha with input-output ratio of 2.41 and 2.60, respectively over farmer's practice of sowing at wider spacing. Under nutrient management, recommended dose of NPK - 80:40:40 kg/ha to American hybrid NHH-44 and 50:25:25 NPK kg/ha to American variety PH-348 recorded an average increase in net returns by Rs. 2756/ha and Rs. 2344/ha with input-output ratio of 2.60 and 2.45, respectively as compared to farmer's practice of sub-normal NPK application, whereas application or recommeded dose of NPK (50 : 25 : 25 NPK kg/ha) to *desi* cotton PA-255 recorded an average increase in net returns by Rs. 1689/ha with input-output ratio of 2.67 as compared to farmer's practice. IPM interventions noted an average increase in net returns by Rs. 3891/ha with input-output ratio of 2.44 over farmer's practice of plant protection. Five point programme intervention showed an average increase in net returns by Rs. 3742/ha with input-output ratio of 2.14 as compared to non-treated plots as farmer's practice. Thus, every intervention proved ecnomically more viable as compared to the farmer's practice.

6.8
Adoptable Srivilliputtur IPM module–a farmers participatory programme in Tamil Nadu

S. SUBRAMANIAN AND S. V. KRISHNAMOORTHY
Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore-641 003

Adoptable Srivilliputtur IPM module, a package developed at Cotton Research Station. Tamil Nadu Agricultural University, Srivilliputtur for summer irrigated cotton tracts of Tamil Nadu was evaluated through farmers participatory programme in two villages *viz.,* Mamsapuram and Chittalamputtur of Virudhunagar district. The IPM package comprised of basal neem cake application @ 150 kg/ha, seed treatment with imidacloprid 70WS @ 5g/kg, 1% neemoil drenching at 20 DAS for management of stem weevil *Pempherulus affini*s, use of trap crops (castor, sunflower, bhindi, red gram), ecofeast crops (maize, cowpea) along the border and bunds to faciliatate the conservation and augmentation of natural enemy population in cotton, use of yellow sticky traps for monitoring whitefly, use of pheromone traps for bollworms *viz.,* American bollworm *Helicoverpa armigera* and pink bollworm *Pectinophora gossypiella,* clipping of terminals at 75 DAS to get rid of American bollworm eggs, two releases of *Trichogramma* and ETL based protection with chemical pesticides. Assessment of sucking pests, stem weevil, bollworms, natural enemy complex were made both in IPM module and farmers practice of plant protection. IPM module registered maximum seed cotton yield of 1960 kg/ha, an increase of 32.4 per cent over faermers practice with 40 per cent reduction in cost of plant protection. Net profit of Rs. 22,100/ha was realized in IPM module compared to Rs 15,500/ha in farmers practice.

6.9
Assessment of watershed- based technology transfer among watershed farmers under Thugaon micro-watershed

S. M. WASNIK AND K. S. BHASKAR
Central Institute for Cotton Research, Nagpur-440 010

Cotton- based cropping system in most of the area suffered form resource constraints and also confronted with a number of problems is rainfed tracts of Maharashtra. The productivity of the system in rainfed agro-eco-system watershed areas is considreably low as compoared to irrigated agro-ecosystem. In rainfed system, watershed management has been accepted as the most rational approach in preventing deterioration of agro-eco-system, restoration of degraded lands; use of rainwater and runoff harvesting. Efficient management has helped in improving overall productivity in rainfed areas. The soil and water conservation measures such as growing of grasses on boundaries, mulching, forestation, ridges and furrow methods, deep tillage, strip cropping, sowing of crops across slope, land leveling, contour farming, collection of excess runoff water in

harvesting ponds, etc are some of the important measures considered for improving the land use efficiency and crop yields at watershed basis. Considering all these facts a comprehensive programme of technology transfer at watershed basis on farmers field at Thugaon micro-watershed in Amaravati district was launched by Central Institute for Cotton Research, Nagpur under NATP Rainfed-agro-eco-system during 2000-2004. For assessment of the technology transfer programme an instrument was developed to record knowledge and adoption of watershed-based technologies. This instrument was used before start and after implementation of the programme in selected villages and farmers under Thugaon micro-watershed. The study revealed that the watershed farmers had higher enhancement of knowledge, adoption and improvement in yield levels in cotton-based crops after implementation of the programme. The score for adoption of technologies ranged from 35-51 per cent before programme initiation and 50-102 per cent after the implementation of programme. However, the composite mean score was increased to the tune of 27.39 and 71.83 per cent, respectively, in case of knowledge and adoption of practices. It was remarkable that due to on-farm trials, an increase of 129, 56.67, 172.73, 44.71 and 114.29 per cent yields, in cotton, jowar, pigeon pea, wheat and gram was recorded, respectively. Further it indicated that the yields obtained in on-farm trials were comparatively higher than the state and the districts average yields. This showed that the watershed farmers could easily double the productivity of most of the crops if the farmers kept pace with watershed based cotton production technology. The positive aspect of the programme was that the other watershed farmers who were not covered under the programme were also taking interests in adoption of cotton based watershed technologies. However, concerted extension efforts are required to popularize the watershed-based cotton production technology among the villagers.

6.10
Transfer of cotton production technology through front–line demonstrations- a case study

S. M. WASNIK, K. K. MESHRAM AND R. K. DESHMUKH
Central Institute for Cotton Research, Nagpur-440 010

The cotton yields in rainfed Vidharbha region is 127 kg lint/kg only as against national average of 300 kg lint /ha. To bridge this gap and improve cotton productivity by guiding the farmers regarding adoption of latest cotton production technologies in Vidharbha districts, CICR Nagpur implemented transfer of cotton production technology programme through one of its unique and innovative programmes i. e. Cotton Front-Line Demonstration (FLD) sponsored by ICAR and Govt of India. The programme implemented at selected 102 farmers field in village Alagondi, Pohi, Rama in Nagpur district and Masala, Umari and Tumgaon in Chandrapur districts during 2000-2004. The selected farmers raised the cotton crop under direct supervision of team of scientists. For other farmers of the villages, demonstrations, field visits, farmers day, RKM and distribution of extension literature were used to make technology transfer an effective programme in the districts/region. The study revealed that cotton FLDs show significant impact on cotton growers. The enhancement on knowledge, adoption and yield levels after programme implementation was significantly higher i. e. 84.29, 95, and 52.78 percent, respectively. Simlarly, fellow farmers also largely benefited due to programme and enhancement was 51.16, 87.06 and 28.79 percent, respectively in knowledge, adoption and productivity. The net profit margin through cotton FLD programme ranged from Rs. 3900 to Rs. 10100 per hectare as compared to pre-programme stage and the average net returns enhanced to 375 per cent due to programme implementation at farmers levels. Severity of pests, uneven distribution of rainfall, high costs of plant protection chemicals, ineffectiveness of plant protection chemcals, high costs of fertilizers, non-availability of fertilizers and good quality seeds, awareness about the beneficial insects for natural control as well as the use of proper chemical for target pests and diseases are some of the major constraints expressed by both beneficiary and non-beneficiary fellow farmers in adoption of cotton technologies.

6.11
Impact of integrated pest management paractices on pests incidence and yield of irrigated cotton

K. L. JAT, KISHORE CHAND, P. D. SHARMA AND S. S. KHARUB
CCS Haryana Agricultural University, Krishi Vigyan Kendra, Fatehabad-125 050

An attempt was made under National Agricultural Technology Project during 2002-03 to evaluate the pest management technology on cotton which was developed and demonstrated in 25 hectares under farmers field conditions at village Hizrawa Kalan (Fatehabad Distt.) located in predominantly irrigated cotton belt of Haryana. The data revealed that the population of leafhopper was low (1.78 nymphs/leaf) in IPM than non-IPM (2.34 nympha/leaf) field and the incidence of whitefly also decreased upto 48.70 per cent in IPM field. The population of *Helicoverpa armigera* was recorded lower in IPM fields (0.41 larva/plant) than non-IPM (0.87 larva/plant) and the beneficial natural enemies also increased in IPM fields. Cultural practices like deep ploughing, field sanitation, sowing of recommended varieties at proper spacing, seed rate, seed treatment with pesticides, balanced fertilizer use, hoeing and weeding, removal of pest and disease infested plants/plant parts in and around cotton field were being followed by the farmers. Farmers were able to identify and monitor insect-pests,diseases and natural enemies. Pest specific use of pesticides at ET was being followed. The use of locally available neem seed as bio-pesticide was encouraged. Farmers have started visiting KVK, University, Department of Agriculture, etc. There was considerable saving (35.90%) in the expenditure on pesticides. The analysis of impact of IPM on yields also indicate that the farmers who adopted IPM have harvested higher yield (15.10 q/ha) than those who not adopted (12.00 q/ha). As a result the return obtained by IPM farmers (Rs. 15561/ha) was higher than those of non IPM farmers (Rs. 7651/ha) which ultimately resulted in higher C:B ratio of 1:3.88 in IPM fields. The use of locally available neem seed as bio-pesticides were encouraged. The success of technology could be visualized with the reduction in pesticide use at village level.

6.12
Evaluation of cotton production technologies for yield and economic viability

VINOD KUMAR GARG, R. K. CHOUDHARY AND S. K. KHAMPARIA
Jawaharlal Nehru Krishi Vishwa Vidayalaya, Regional Agricultural Research Station, Khnadwa-450 001

Cotton is an important cash crop grown in about 6.23 lakh hactare area with total production of about 15 lakh bales (in the year 2001-02). To attain sustainable maximum productivity of cotton in Madhya Pradesh, eleven interventions on different aspects of INM, IPM and crop management were undertaken on farmer's field of 110 farmers of village Malgaon Temi, Khandwa during 2001-03. Each and every intervention had its own impact on cotton production. Use of well decomposed FYM/NADEP compost @ 10 t/ha increased the seed cotton yield to a tune of 21.35 per cent over farmer's practice, followed by adoption of integrated pest management technology (16.50% increase in seed cotton). Growing of jowar or maize as bird percher added 3.68% seed cotton yield without increasing the cost of cultivation. Cost : benefit ratio of 1 : 1.75 and 1 : 1.65 were obtained with the use of well decomposed FYM/NADEP compost and IPM interventions, respectively, while it was 1 : 1.06 under farmer's practice.

6.13
Constraints in adoption of IPM practices on cotton in East Nimar region of M.P.

YOGESH PATEL, R. K. CHOUDHARY, V. K. SHRIVASTAVA AND V. K. GARG
Jawaharlal Nehru Krishi Vishwa Vidayalaya, Regional Agricultural Research Station, Khandwa-450 001

Integrated pest management is an important approach of checking pests which plays a crucial role in producing sufficient quantities of food to sustain our growing population. A survey was conducted in ten village of East Nimar region of Madhya Pradesh during 2002-2003 to identify major constrains in the adoption of IPM technology in cotton. The major constraints ecnountered by the cotton growers can be categorized into three major classes : socio-economic status, lack of awareness and availability of quality agricultural inputs. Due to small land holdings, crop rotation was a major constraint for them. This was followed by unavailability of seeds of recommended varieties and if made available by the Government agencies it was not made available at the proper time. Inappropriate use of fertilizer, generally excessive use of nitrogenous fertilizer, aggravated the pest incidence. If irrigation facilities were available the farmers went for flood irrigation frequently.
Farmers generally felt that there was no alternative to the chemicals. Non-judicious use of insecticides, mixing a number of insecticides and mentality of relying heavily on the use of insecticide had complicated the problem. They are unaware of the development of the resistance, pest resurgence and residual effect of the chemicals. Further, majority of the farmers took advice from insecticides dealers for applying pesticides and availed credit facility from the dealers. They were also unaware of the need of a healthy environment, human and animal health. It is, therefore, suggested that these constraints should be eliminated by popularizing the IPM technology. The awareness of farmers could be improved through continuous training programme and field demonstrations of low inputs, effective IPM module in different farming situations, etc. Once the farmers accepted the technology, they would spread the technology among the cotton growers.

6.14
Assessment of transfer of technology of cotton in Nimar valley of Madhya Pradesh

RAKESH K. SHARMA AND N. K. GUPTA
Jawaharlal Nehru Krishi Vishwa Vidhalaya, Krishi Vigyan Kendra, Khandwa-450 001

The Nimar valley of Madhya Pradesh is also known as cotton-jowar crop zone. Cotton is the most important crop occupying 80 per cent rainfed area which is 75 per cent of the area under cotton in the state but productivity is very low (471 kg lint/ha) The major constraints identified for low productivity are given below.
About 80 per cent area under cultivation is rainfed, undulated topography of land with poor nutrients status, shallow soil depth, poor water retention capacity of soil due to high infiltration rate, high run off and leaching losses, unprecedented climatic condition such as long dry spell or heavy rainfall, never ending problem of insect pests, and non adoption of latest production technology.
Krishi Vigyan Kendra Khandwa made an endeavour to transfer latest production technology of cotton through conducting front line demonstrations on different component of cotton production like FLD on full package, inter cropping of cotton with soybean, introduction of new varieties/hybrids, IPM and *in-situ* moisture conservation practices, etc at different locations (farmers field) of Nimar valley during 1999-2004. The results of these demonstrations revealed that there existed tremendous scope for increasing the productivity of cotton to the extent of 40 per cent, the highest increase being 54% in yield under full package of demonstration. About 18 per cent increase was noticed due to inter cropping of cotton with soybean (1:1). Increase in yield was observed due to IPM practices (28%), *in-situ* moisture conservation practices (14%) and introduction of new varieties/hybrid (24-29%). It was concluded that the production of the cotton could be sustained with incorporation of different aspects or components of low input production technology of cotton and economic status of the farmers of Nimar valley of Madhya Pradesh could be upgraded.

6.15
Cognitive domain of cotton growers with respect to integrated pest management

B. M. KHADI, FAROOK NIMBAL AND S. S. UDIKERI
University of Agricultural Sciences, Resional Agricultural Research Station, Dharwad-580 007

In India cotton is cultivated in a wide range of agro-climatic situations and it is as ancient as the human civilization. Agricultural universities, private and public sector organizations have produced good number of hybrids/ varieties of cotton which are capable of bringing high gross monetary benefits to the growers. These hybrids/varieties are more input responsive because of which the crop exhibits luxuriant growth and becomes more vulnerable to attack of pests and diseases. Most farmers use more than recommmended dosages of chemicals which cause pest resurgence, destruction of natural enemies and beneficial insects. Agricultural scientists are recommending judicious use of chemicals as a component of integrated pest management (IPM). Hence, the present study was undertaken to find out congnitive domain of cotton growers with respect to IPM technology. The study indicated that cotton growers were in a take-off stage regarding knowledge of IPM technology as such but majority of them had poor knowledge of different components of IPM. New strategies such as extension participation, cotton scientists meet, informal training, field days, success stories of farmers and innovativeness must be manipulated to increase congnitive domain of the farmers with respect to IPM practices. Farmers' field school appraoch (FFS) will paly a much convincing role in this regard.

6.16
Use of pesticides in cotton in Fatehabad district of Haryana

KISHOR CHAND KUMHAR, S. N. NANDAL, M. S. CHAUHAN, P. D. SHARMA, S. S. KHARUB AND KISHAN LAL JAT
CCS Haryana Agricultural University, Krishi Vigyan Kendra, Fatehabad-125 050

Cotton is an important cash crop of Haryana. It affects the economic condition of farmers to a great extent. Its average yield in India is very low (153 kg lint/ha) as compared to world (411 kg lint/ha). Its production and quality is affected by a number of factors such as climatic conditions, seed qualtiy, agronomic practices, attack of insect-pests, disease and agochemicals used to protect the crop. In cotton leafhopper (*Amrasca biguttula*), whitefly (*Bemisia tabaci*), spotted bollworms *(Earias* spp.), pink bollworm (*Pectinophora gossypiella*) and American bollworm (*Helicoverpa armigera*) are important pests while among diseases root-rot (*Macrophomina phaseolina, R. bataticola, R. solani)* bacterial blight (*Xanthomonas campestris*), Myrothecium leaf spot *(Myrotecium roridum*), Alternaria leaf spot (*Alternaria macrospora*) and Fusarium wilt (*Fusarium oxysporum)* cause significant loss.

To find out the use of pesticides for the management of the insect-pests and diseases, survey under NATP Mission Mode Project was carried out in cotton field of village Hizrawan, Dhani Dhaka, Dhani Issar, Dhani Chhatrian and Daulatpur from year 2001 to 2003 in the crop seasons at weekly intervals. For this purpose farmers were categorized into two groups i. e. IPM farmers and non-IPM farmers. Each group had 20 farmers. It was noticed that approximately 80 per cent IPM farmers treated the cotton seeds with Streptocycline (1g), Vitavax (2g/kg seed), *Trichoderma viride* (4g/kg seed) resulting in 9.35 per cent disease complex while 30 per cent non-IPM farmers treated the seed and the disease incidence was 26.03 per cent. Copper oxychloride was sprayed 2-3 times by IPM farmers while 3-4 sprays were carried out by non-IPM farmers when leaf spot appeared.

To control the insect-pests IPM farmers on an average applied 7.22 sprays (imidacloprid, dimethoate, endosulphan, quinalphos, triazophos, profenophos and neem products) while non-IPM farmers carried out 10.78 sprays (monocrotophos, fenvalerate, imidacloprid, quinalphos, dimethoate, endosulphan, avaunt, spinosad, larvin, decamethrin and cypermethrin). It was also noticed that non-IPM farmers mixed 2-3 pesticides without taking pest situation into consideration and sprayed their crop at an interval of 3-4 days while IPM farmers sprayed crop according to pest situation without mixing of pesticides at an interval of 7-15 days.

6.17
Different phases of cotton cultivation in Punjab

B. S. SEKHON AND PARAMJIT SINGH
Punjab Agricultural University, Regional Station, Bathinda-151 001

Cotton cultivation in Punjab has traversed the same path as in most of the other cotton growing regions of the world. Starting from subsistence farming the crop has passed exploitation phase, crisis phase, disaster phase and now entering IPM phase. In the subsistence phase, the farmers remained contented with growing *desi* cotton (*Gossypium arboreum*) for centuries which was mainly grown for family needs. The exploitation phase started with the introduction of American cotton (*Gossypium hirsutum*) by East India Company in mid ninteenth century. The introduction was made to ensure steady supply of long staple cotton to England's textile Industry and due to its soft feel the popular variety of American cotton grown in Punjab came to be known as *narma* which culminated in the development of 3F and 4F varieties. Out of these, 4F rapidly spread in Punjab as it had coarse and hairy leaves which provided it resistance to cotton jassid. The isolation of LSS variety from a field of 4F acutely affected by 'Tirak' disease, became a big hit in joint Punjab and continued to be grown in Indian Punjab even after partition. But its susceptibility to cotton jassid led to its downfall. The phase reached its culmination with the breeding of high yielding, early maturing, good staple, drought resistance varieties and the introduction of synthetic pyrethriods in the mid eighties. The appearance of American bollworm, *Helicoverpa armigera* in about 20 villages in the now Muktsar district of Punjab in 1977 started the crisis phase in the state. The crisis deepened when in 1983 in many of the cotton growing areas there was more than 50 per cent crop loss. Though the crop yields improved in the subsequent years till 1996 but during this period very high incidence of bollworms, especially American bollworm, resulted in crop failures during 1988, 1990 and 1993. The increasing population of bollworms compelled the farmers to rely more and more on highly potent, wide spectrum inscticides and their mixtures which, in turn, increased the problem of resistance and pest resurgence. The high incidence of jassid, whitefly and bollworms complex by increasing the cost of cultivation on plant protection pushed the crop in the disaster phase. This necessitated the implementation of IPM strategies in cotton cultivation, which were promoted by Punjab Agricultural University and Agriculturre Department of Punjab. Keeping in view the high potential of profit in the crop, private companies also helped in the introduction of short duration, high yielding hybrids, which escaped the incidence of key pests. In chemical control also some new insecticide are proving effective against key pests. The revival of remunerative cultivation of cotton is again picking up since 2002.

6.18
Cotton cultivation in Punjab–a historical perspective

PARAMJIT SINGH AND B. S. SEKHON
Punjab Agricultural University, Regional Station, Bathinda-151 001

Punjab remained content with the growing of short staple *desi* cotton (*Gossypium arboreum* L.) for centuries, which met her normal needs till mid ninteenth century. To find out an alternative source of supply of long staple cotton to England's textile industry, the East India Company laid out extensive trials with exotic cottons in different parts of India at that time. The first attempt in Punjab was made in 1853 and the popular variety of American cotton grown in Punjab came to be known as *narma* due to its soft feel. Selection work started at Lyalpur in 1912 resulted in the development of 3F and 4F varieties. The variety LSS, result of single plant selection by Shri Labh Singh in 1928 from a field acutely effected by 'Tirak' (bad opening of bolls) was a landmark in the history of the Punjab American cottons. The partitioning of the country in 1947 snatched major cotton growing areas from the present Punjab. LSS was the only variety of upland cotton that had found its way on some area in Ferozepur district. Efforts to extend the cultivation of LSS to other areas did not succeed because of its longer duration and susceptibility to cotton jassid. Breeding work was started in 1948

and as a result a number of varieties like 216 F, 320F, LL54, J34, J205 were developed which took about 210-270 days to mature. During late sixties, the incidence of bollworms was picking up and the cultivation of these long duration varieties was greatly instrumental in the further spread of this menace. Moreover, the pressure of double cropping also necessitated the cultivation of short duration varieties. Selection was conducted on the non-descriptive variety Bikaneri Narma and the variety F414 was released in 1977, which took 180-190 days to mature and was fit in double cropping pattern. Keeping in mind the profitable cotton-wheat rotation, short duration varieties LH372, F286, F505 and LH886 were developed and released for cultivation in state. The first short statured, short duration and early yielding variety, LH900, was recommended for general cultivation in 1985 which bacame very popular among the farmers of Punjab and the neighbouring states. Later during early nineties, the research efforts were intensified to develop high yielding, early maturing varieties possessing superior medium quality combining resistance to insect pests and diseases. The work resulted in the development and release of superior medium varieties like LH1134, F846, F1054, LH1556, F1378 and F1861. The large scale adoption of these varieties alongwith improved production technology increased cotton production from 2.54 lakh bales in 1950-51 to 24.54 lakh bales in 1989-90. Though the crop yields were good till 1996 but very high incidence of bollworm, especially American bollworm, almost failed the crop during 1983, 1988, 1990 and 1993. The increasing population of bollworms compelled the farmers to rely more and more on highly potent insecticides and their mixtures, which in turn increased the problem of resistance and pest resurgence. This necessitated the implementation of IPM strategies for bollworm complex and cultivation of short, compact and early maturing varieties. Keeping in view the high potential of prifit in the crop, some private companies also helped in the introduction of short duration, high yielding hybrids, which escaped the incidence of key pests. The revival of remunerative cultivation of cotton is picking up since 2002 relying on these strategies.

6.19
Development of *Gossypium hirsutum* hybrids for north India

JAGMAIL SINGH, R. P. SING AND PUNEET LUTHRA
Division of Genetics, Indian Agricultural Research Institute, New Delhi-110 012

India is the first country in the world to have successfully exploited hybrid vigour in cotton. The first *intra hirsutum* hybrid 'H-4' was developed and released for commercial cultivation in 1970. This was followed by the development and release of interspecific hybrid 'Varalaxmi' in 1972. A number of intra and interspecific hybrids have since been released for commericial cultivation in Central Zone and Southern Zone.

Research efforts have also been made for the development of suitable hybrids for northern India which is predominantly irrigated and the improved varieties recommended for cultivation have high yield potential of 25-30 q/ha. The hybrids for this region, therefore, must have at least 20 per cent yield superiority over the exsiting varieties and should mature in the same period to make them economically viable. Although a number of hybrids like Fateh, HHH-81, Maru Vikas, LHH-144 and OM Shankar, etc have been released in northern zone, nonetheless, these hybrids failed to occupy any significant area in this region because of high cost of seeds and limited boll setting period due to onset of winter by middle of November.

The experimental data from AICCIP varietal trails Br02(a), Br03(a) and Br04(a) and hybrid trials Br05(a-1) and Br05(1-2) from 1999-00 to 2003-04 were crtically examined to see the performance of hybrids against the varieties (under testing). The average seed cotton yield during the five years period (1999-00 to 2003-04) in different varietal trials was compared with that of *intra hirsutum* hybrid trials, both conventional and MS based. The maximum superiority of highest yielding hybrid over the highest yielding variety was observed to be 14.6 per cent in trial Br04(a) *vs.* Br 05 (a-1) (conventional hybrids) whereas the comparison of average of top five entries showed 12.7 per cent yield superiority of conventional hybrids over varieties in Br04(a) vs. Br05(a-1). The increase in seed cotton yield of highest yielding hubrid over highest yielding variety and average of top five ranking hybrids over average of top five ranking varieties in Br03(a) *vs.* Br05(a-1) was found to be 9.9 and 11.2 per cent, respectively, whereas it was 1.7 and 3.1 per cent in comparison to Br05(a-1)

vs. Br02(a). This, however, needs to be seed in the light of yield levels of checks. The average yields of the local in Br05 (a-1) were lower by 47.15, 43.3 and 41.1 per cent than that of the local checks in varietal trials Br02(a), Br03(a) and Br04(a), respectively. The average of experimental hybrids is superior only by 14.10 and 12.8 per cent in comparison to top ranking variety and over the top 5 varieties in Br04(a), respectively. Their superiority is only marginal when compared to varieties in Br02(a). Hence, there was a need to develop better hybrids with at least 20 per cent superiority over the varieties. The inclusion of varietal checks (zonal and local) in hybrid trials, therefore, merits consideration to ensure comparison with the best released varieties. A similar comparison of varietal trials with that of MS based *intra hirsutum* trials Br05(a-2) showed that the yield of these hybrids was lower as compared to the corresponding yield in all varietal trials. This evidently suggested lower yield potential of MS- based *intra hirsutum* hybrids under evaluation in the AICCIP trials in the northern zone as compared to that of varieties.

6.20
Prospects of CMS based semi okra leaf hybrids in upland cotton (*Gossypium hirsutum* L.) in China

YAGYA DUTT, WANG XUE DE. NI XI YUAN, X. ZHAO AND K. S. NIRANIA
Department of Agronomy, College of Agriculture & Biotechnology, Zhejiang University, Hangzhou-3100 29, China

Cotton is one of most important and extensively grown cash crops of China. Leaf morphology can significantly affect yield, quality, maturity, pest preference, canopy penetration of plant growth regulators, and other important production characterstics of many crops including cotton. Tetraploid cottons have two major leaf types: normal and okra leaf. Normal leaf is also called broad leaf and is predominant among cultivated cottons. The present study was conducted to know the effect of okra/semi okra leaf type on yield and its contributing traits in CMS based hybrids in cotton. In the present investigation, 14 hybrids (seven semi okra and seven normal type) were grown in a randomized block design with three replications at experimental farm of Zhejiang University, Hangzhou, China. The results showed that semi okra leaf type hybrid ZJU 70 gave highest seed cotton yield. The comparision of average yield of normal leaf hybrids with the average yield of semi-okra leaf hybrids revealed that there was no significant difference in the average yield of semi okra leaves hybrids and normal leaf cotton hybrids. But our observation and some earlier reports indicated that semi okra leaves matured earlier than that of normal leaf cotton hybrids, possibly contributing to their over all yield advantage. Thus, if we calculate seed cotton yield/plant/per day, semi okra leaves have more yield as compared to normal leaf type cotton F_1 hybrids. Semi-okra leaf cotton hybrids can reduce the production costs because these matured earlier without sacrficing yield. The results indicated that semi-okra leaf traits should be considered for producing further cultivars. There is need to generate more data to draw better conclusion on this aspect.

6.21
Development of sustainable technology for organic farming in cotton based cropping system in rainfed farming

R. K. DESHMUKH, M. R. K. RAO, SUMANBALA SINGH, P. R. VIJAYAKUMARI, M. K. MESHRAM, VINITA GORMARE, P. SINGH AND V. SANTHY
Central Institute for Cotton Research, Nagpur-440 010

In the recent past, organic farming/natural farming has gained considerable importance all over the world primarily to mitigate the adversities of intensive cultivation practices (having emphasis on inorganic nutrients and inputs) with particular reference to ecological, environmental, health and sustainability concerns. In this context efforts were made to develop viable technology for organic cotton production at CICR Nagpur. The studies were conducted over a five year period with many promising cultures under organic and inorganic conditions. In the organic system the nutrient supply was through FYM while pest management was undertaken with the use of biopesticides. In the inorganic system the recommended practices were followed. Even though the average yield in the inorganic system was slightly higher than the organic system over the

five year period, the organic system reached the level of inorganic by the third year and surpassed inorganic in the fifth year. On the other hand, the organic system when rotated with the green manure crops in alternate years, led to further enhancement in yield realization especially in the first and fifth years, as compared to organic and inorganic systems. Considerable variability was evident in respect of response of different cultures to the organic system of cultivation. Thus, in the relatively low productivity zones (such as rainfed tracts of central zone) organic cotton farming can become a viable option and if proper incentives are provided it may become popular as well.

6.22
Package of practices for ecofriendly organic cotton under summer irrigated conditions

R. S. RAUT, J. G. THOKALE AND S. S. MEHETRE
All India Co-ordinated Cotton Improvement Project, Mahatma Phule Krishi Vidhyapeeth, Rahuri-413 722

During the era of sustainable agricultural it is necessary to focus attention towards organic farming of cotton. With this view in mind an experiment on package of practices for ecofriendly organic farming under summer irrigated conditions was conducted during 1999-2000 to 2003-2004 at Rahuri. The experimental design was RBD, which comprised of six treatments and four replications. The soil was medium deep black, low in available nitrogen, medium in available P_2O_5 and high in available K_2O. The cotton hybrid used was NHH-44. It was concluded that highest seed cotton yield (19.03 q/ha) was recorded from the treatment having 50 per cent N through organic sources [FYM 5 t/ha + *Azotobacter* + *Azospirillium* + PSB (seed treatment)] and 50 per cent N through inorganic sources (50 kg N through urea). All the growth and yield contributing characters were significantly influenced by this treatment. Maximum gross monetary returns (Rs. 47575/ha), net monetary returns (Rs. 21910/ha) and benefit-cost ratio (1.85) were recorded in this treatment.

6.23
Promotion of diploid cotton varieties for organic cultivation in Madhya Pradesh

G. K. KOUTU, PANKAJ SHAH, N. K. BISEN, D. S. TOMAR AND RAJANI TOMAR
Jawaharlal Nehru Krishi Vishwa Vidhyalaya, Main Cotton Research Station, Khandwa-450 001

With the introduction of American cotton in India in the forties and subsequent large-scale cultivation due to its yield potential and fibre quality, the erstwhile diploid cotton cultivars were pushed to the background. In the seventies, again with the advent of hybrids (*intra hirsutum*), nearly 80% of the total area came under *hirsutum* species. This species though high yielding with good fibre quality had its inherent drawbacks. The varieties and hybrids of this species requirwd high fertilizer doses and were highly susceptible both to the sucking pests and bollowrms complex. The indiscriminate use of insecticides to control the pests increased the cost of cultivation on one hand and gave rise to resistant strains and economic cultivation of cotton became a difficult task. The demand of organic cotton is growing very fast worldwide. A study was therefore, undertaken for the promotion of diploid cotton cultivars for organic cultivation, which are known to respond very well to loe input technology.

In the present investigation, organic cotton production technology was tested in the farmers fields. Ten farmers of Burhanpur were selected for the purpose. *Desi* cotton variety Jawahar Tapti and Sarvottam were chosen. The farmers were educated to use manures, botanical insecticides, biofertilizers, trichocards, HNPV, pheromone traps and use of acid delinted seed for optimum plant population. The study revealed that diploid cotton cultivars could be successfully grown organically without compromising the yield and fibre quality. The farmers were found to be satisfed with the diploid cultivars, Jawahar Tapti and Sarvottam, as compared to the *hirsutum* varieties that are being widely grown.

6.24
Challenges of marketing Indian cotton internationally

D. C. TALOLE, S. S. MEHETRE AND T. V. G. SARMA
All India Co-ordinated Cotton Improvement Project, Mahatma Phule Krishi Vidhyapeeth, Rahuri-713 422

Cotton production in India has made giant strides since independence, particularly in 1970s. An innovative approach in the improvement and development of the crop has led to a breakthrough in the quality and quantity of production. The total output of cotton registered many fold increase from about 2.3 million bales in 1947-48 to around 17.8 million bales in 1977-78. India is now producing about 12.50 million bales of long and superior long staple cotton whereas not even a bale of such cotton was produced till the early 1950s. Per hectare cotton yield has also gone up by 72 per cent from 90 kg in 1947-48 to 155 kg in 1977-78 and further increased to about 322 kg in the year 2002-03. These credentials have been achieved mainly by the use of improved technology, expansion in irrigated cotton area and the development and extension of new high yielding varieties. Cotton is a major cash crop grown in India on an approximate area of 8.5 to 9.0 million ha and provides livelihood for about 4 million households. Allied activities like ginning, yarn and fabric production, textile processing, garment manufacture, marketing etc. provide employment to about 60 million people. The antiquity of Indian cotton is traced to the ancient Indian civilization of 3000 B. C. Even though the cotton productivity in India has increased many fold but the total production has not shown continuous increase as it has been fluctuating in recent past owing to the rainfall and climatic fluctuations. Comparing the cotton productivity of India to that of the different countries in world is found less than half the productivity of China which is number one. Emergence of WTO in January 1995 has also come out with new challenge to the Indian cotton sector. Agreement on Agriclture under WTO regime will privide an access for international players. Unfortunately the agriculture sector of India has not so far been liberalized and cotton export is highly regulated. Productivity cost of cultivation and issues related to length also have to be addressed to. The use of sanitary and phyto sanitary measures by importing countries will also be an important challenge for cotton export in the future to come. The revised estimates of USDA have predicted shortage in world cotton availability attributed to the decline in production estimates of U. S. (3.09 m bales) and India (1.7 m bales). Cotton in India has a vital place in its foreign trade earning about 20 per cent of country's export receipts. India the third largest country in the cotton production with 25 per cent of the world's cotton area and 16 per cent of production can have a lion's share in world cotton economy if the production and productivity targets are met. In the present paper we have attempted to find out the significance, emerging trend and challenges of cotton in the economy of India and the role of Indian cotton sector in the world cotton and textile economy which India can have in the future to come.

6.25
A success story of IPM on rainfed cotton on a whole village approach system in drought prone areas of Maharashtra

U. N. MOTE AND S. N. PURI
Department of Entomology, Mahatma Phule Krishi Vidyapeeth, Rahuri-413 722

Integrated pest management (IPM) plays a major role in crop production as it preserves natural biodiversity with sustainable agriculture, apart from reduceing the cost of pest management. There are a numer of reports on successful IPM programmes against different pests on major crops in different states of this country, but these are scattered demonstrations, covering an acre of a crop in a village. An IPM module on rainfed cotton comprising of cotton hybrid, Ajit-33, seed treatment of imidacloprid 70 WS 10 g/kg of seed, inter and mixed cropping of cowpea, maize, sorghum, bajra and *Setaria,* sowing within a week in the whole village, pheromone trap @ 5/ha and 2-3 sprays of NSE 5% was tested at Varur, Tehsil Shevgaon, Dist. Ahmednagar during 2002-03. The IPM was taken on 50 ha belonging to 36 farmers. The sucking pests population as well as bollworms incidence was quite low in IPM fields as compared to farmers practice fields. IPM farmers got an additional cotton yield and income of 9.40 q/ha and Rs. 17025/ha, respectively. Motivation from this programme enabled

farmers of Varur and adjoining villages in Shevgaon Tehsil to take their cotton crop under full umbrella of IPM. During 2003-04, the IPM on rainfed cotton was taken on 2100 ha in 8 villages (Varur-415 ha, Akhegaon-614 ha, Kharadgaon-152 ha, Hatgaon ha, Sonvihir-45 ha, Bodhcgaon-40 ha, Balamtakli-35 ha and Kambi-551 ha), comprising of 2092 farmers fields. The rainfall received during this year was 250-350 mm only. IPM cotton farmers did not spray any chemical pesticide, except seed treatment with imidacloprid. The addition of inter and mixed cropping of sorghum, bajra and maize was done. The crop condition was excellent and there was no any serious pest problem in the IPM cotton crop. The yield levels were from 8 to 30 q/ha with an average of 17 q/ha in IPM fields, while it was 10 q/ha in non-IPM fields. The net gain was Rs. 17500/ha. The whole programme was taken without any financial help from any agency. There was a horizontal spread of IPM technology among the farmers.

6.26
Technology and cotton production efficiency in Tamil Nadu–assessing varietal adoption and competitiveness

K. N. SELVARAJ, M. PRAHADEESWARAN AND G. SOMASUNDARAM
Department of Agricultural Economics, Tamil Nadu Agricultural University, Coimbatore-641 003

Rising level of technology has not adequately helped the cotton production industry to grow efficiently as evident from the stagnation in productivity. Inefficieny in cotton production and its low level of profitability are reflected in area allocation. Area under cotton declined at the rate of 4.2 per cent and 2.2 per cent exponentially from 1976-77 to 1985-86 and 1986-87 to 2000-01 in Tamil Nadu, respectiviely. Country and the state suffered from low productivity levels and the productivity was stagnant in India, while it declined at the rate of 0.32 per cent in Tamil Nadu between 1986-87 and 2000-01. This resulted in large scale imports of cotton and it was estimated that imports grew at the rate of 25.68 per cent during 1990s. Exports witnessed a negative growth rate of 19.75 per cent during the same period due to production stagnation and increasing demand, which grew at the rate of 1.89 per cent and 3.96 per cent, respectively leaving a high demand and supply gap. Studies also proved that due to yield gap, production loss was 60 lakh bales per annum. The results of sample survey indicated that the yield gap for major varieties varieties (LRA 5166, MCU 5, MCU 7 and Suvin) of Tamil Nadu varied between five to ten quintals of *kapas*/ha. Among the varieties LRA 5166 was widely adopted by the farmers (51%), followed by MCU 5 (28%), Suvin (11%) and MCU 7 (10%). Area under cotton in Tamil Nadu was 2.21 lakh hectares, of which LRA 5166 accounted for 44 per cent, followed by MCU 5 (23.33%), MCU 7 (6.2%) and Suvin (3.79%). Area under all these major varieties exhibited negative growth rate. Multinominal Logit Model proved that soil type, duration, irrigation and season influened the varietal adoption. It was found that LRA 5166 was cultivated in rainfed condition during the winter season, predominantly in black soil. MCU 5 and MCU 7 were cultivated under irrigated condition. MCU 5 was mostly cultivated in alluvial soil during summer, while MCU 7 in black and alluvial soil during winter season. Under the international trade regime cotton was found to have comparative advantage as evident from the estimates of Domestic Resource Cost and Effective Rate of Protection. These estimates revealed that there existed incentives for factors to be pulled in to production of cotton and it was less costly to produce cotton in terms of domestic resources than to import. Price policies (ratio of minimum support prices of paddy, wheat, sugarcane to cotton) have not discriminated cotton against food grains and other commercial crops like sugarcane. Therefore, it was imperative that how best the present policies and research can translate cotton into most efficient crop so that the bulk of imports could be minimized. In this context, a thorough understanding of the performance of *Bt* cotton is crucial. Though there are differences in terms of economics of production of *Bt* cotton, large scale production of market demand driven cotton is essential to meet the domestic demand. Present production structure shows that production of long staple cotton forms 40 per cent, followed by superior medium (28%) and medium (20%). So, breeding varieties with medium and short staple cotton is important to meet the market demand.

6.27
Change in the control of American bollworm, *Helicoverpa armigera* (Hub.) in India and its management through surveillance

R. S. JAGLAN
Department of Entomology, CCS Haryana Agricultural University, Hisar-125 004

The American bollworm (*Helicoverpa armigera* Hub.) is a polyphagous pest and cause serious damage. It is known all over the world as one of the most common and harmful pests. The infestation of this pest was not so severe in the past but after 1970's the pest spread through out India with the start of year-round growing of suitable crops and with the enlargement of the cultivated area. It became one of the most persistent insect pest after the 1980's due to development of resistance against pesticides. As a result pesticides application every other weak has become common especially in cotton, being normally sprayed 10-20 times or more in a cropping period. Due to reduced effectiveness, a mixture of 2-3 kinds of pesticides is also often sprayed by the farmers. The pesticide use since 1980 has changed rapidly, starting with organochlorine organophosphates carbamates, synthetic pyrethroid and now moving to BT, IGR and newly registered microbial pesticides.

In India, control of *H. armigera* to-date relied heavily on agricultural chemicals, which required replacement by new effective pesticides approximately after every 2-3 years. Although several effective pesticides are registered at present, the problem relating to resistance induced by selection with pesticide control will continue to persist if not checked properly. The suppression of the pest population below control threshold through the proper combination of different control techniques and by adopting effective monitoring by regular surveillance of the pest can help to achieve this goal to great extent in making IPM programme a success. Given more definite information about the best time and chemicals to use, farmers would be able to apply chemical more efficiently and in many cases at reduced level costs. Thus, pest surveillance offers considerable scope for improving pest control decision making both in relation to ahort-term pest problem and also those associated with long-term changes in crop production.

6.28
Economics of cotton in poly culture crop system in relation to integrated pest management

V. K. SHRIVASTAVA, S. P. S. TOMAR AND A. S. YADAV
Jawaharlal Nehru Krishi Vishwa Vidhayala, B. M. College of Agriculture, Khandwa-450 001

The cotton monoculture is known to encourage more insect pests than polycultures such as cotton-rice, cotton-groundnut and cotton-cowpea or cotton-soybean. Cowpea as an intercrop in the cotton system not only favours colonization by the Coccinellid predators, but increases the degree of natural parasitization of *Earias vittella* Feb. In view of the above concept, field trails were conducted during *kharif* 1996 to 1998 at farmers field under National Watershed Development Research Project, Kaldakhedi, Khandwa (M. P.) to workout the economics of soybean as intercrop in cotton and to develop package of integrated pest management practices to combat the cotton pest complex. It was found that soybean as intercrop in cotton alongwith other integrated pest management (IPM) pracitces not only minimized the incidence of pest but also increased the yield of cotton with higher monetary returns compared to non-integrated pest management approach (i. e. farmers traditional method of pest control). The results indicated that the monetary returns from the IPM adopted plot were Rs. 20745/ha as compared to Rs. 6110/ha in non-IPM plot. This was because of the higher cotton yield, and bonus returns from soybean crop and less number of sprays of insecticides.

6.29
Evaluation of location specific IPM modules for eco-friendly cotton production

S. MOHAN, M. SUGANTHY AND N. NAGAPASUPATHI
Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore-641 003

Studies on the evaluation of location specific integrated pest management (IPM) modules for eco-friendly cotton production were carried out at the farmer's at Palakarai village in Erode district. The strategies included in the IPM module were : acid delinting, seed treatment with *Trichoderma viride* and *Azospirillum,* soil application of *Azospirillum,* planting of green gram as intercrop, castor as trap crops and sorghum as eco-feast crop, foliar application of five per cent neem seed kernel extract (NSKE), release of *Trichogramma chilonis,* use of pheromone traps for *Helicoverpa armigera, Pectinophora gossypiella* and only one spray with chemical pesticide i. e. endosulfan. In non-IPM plots six rounds of pesticides sprays, two for sucking pests and four for bollworms were given. The results revealed that the mean aphid population was about 1.2/ plant in IPM plots as compared to 16.3 in non-IPM plots. The population of natural enemies *viz.,* coccinellids, spiders and *Chrysoperla carnea* were higher in IPM plots. Mean population level of 8.2, 2.8 and 0.4 per plant were noticed for coccinellids, spiders and *Chrysoperla carnea,* respectively, whereas it was 3.33, 0.8 and 0.2 per plant in non-IPM plots. The mean square damage was found to be 3.7 per cent in IPM plots as against 7.5 per cent in non-IPM plots.

6.30
Insecticide resistance management in Haryana

D. MONGA, P. JEYAKUMAR, K. K. DAHYIA, KASHMIR SINGH, AMAR SINGH, BHARAT LAL, BABU LAL AND DEVA RAM

Central Institute for Cotton Research, Regional Station, Sirsa-125 055

Sustainable cotton pest management has become contentious over the two decades in India. The problem has become more acute on account of the development of insecticides resistance to insects. In such a predicament, insecticide resistance management (IRM) assumes significance if pest management programmes are to be successful. The technology desgined for implementation is a relatively simple knowledge intensive package. It includes farmers training in the identification of insect pests and their natural enemies, the applilcation of economic threshold levels in spray decisions based on susceptibility levels and general agronomic management. Implementation of IRM strategies was carried out in ten villages each in three districts of Haryana over a period of two years and data on the pests, predators, insecticide use pattern and cost benefit ratios from participatory and non participatory farmers fields were collected. The population of sucking pest and bollworms was less in participatory farmers fields whereas the population of natural enemies like spiders, *Chrysoperla* and coccinellids was in general higher in participatory farmers fields as compared to non participatory farmers fields. During 2002-03 crop season, the increase in seed cotton yield amongst participatory farmers ranged between 4.6-4.8%, the reduction in number of insecticidal sprays ranged from 3.07-5.05. The cost benefit ratio of participatory farmers varied from 1 : 2.72 to 1 : 3.13 where as in non participatory farmers it varied from 1 : 2.23 to 1 : 2.50. Similar trend was noted in 2003-04 season also but with better improvement of upto 16.3% in yield of participatory farmers over non participatory farmers. The reduction in number of sprays ranged from 3.67 to 4.24. The cost benefit ratio of participatory farmers were also better as compared to previous year and varied from 1 : 3.54 to 1 : 4.63 where as in non participatory farmers it varied between 1 : 2.80 and 1 : 3.73.

6.31
Role of light trap in cotton IPM and the effect of lunar cycle

P. JEYAKUMAR , SUBASH CHANDER , B. L. MEENA, TARUN VERMA, D. MONGA AND T. P. RAJENDRAN
Central Institute for Cotton Research, Regional Station, Sirsa- 125 055

The behaviour of certain species of cotton pests especially bollworms attracted to light could be advantageously used in their management. A light trap is an important tool to monitor the activity of adult insect pests, which are active fliers and higly phototrophic in nature. However, light trap also attracts many beneficial and non-target organisms like parasitoids, predators and pollinators along with insect pests. The daily light trap catches of phototactic insects are further influenced by the intensity of moon light associated with the daily changes in the degree of moon phase in lunar cycle. Keeping this in view a study was conducted during the two cotton seasons (2002 and 2003) to know the range of insects attracted to light trap as well as the effect of moon light on the efficacy of light trap.To carry out this study a light trap was operated throughout every night in the farm area of Central Institute for Cotton Research, Regional Station Sirsa, during cotton crop season 2002 and 2003.

The data revealed that about 37.24 per cent of the total insects trapped in light trap consisted of bollworms. American bollworm (15.96 %) and spotted bollworm (14.85 %) formed the major chunk of the bollworm complex as compared to pink bollworm (6.43%). The beneficial insects such as *Chrysoperla carnea* (0.05%), wasp (1.81%), honey bees (3.19%) were also attracted into the light trap.

The number of each bollworm traped during full moon weak was around 2-2.6 times less than that of corresponding trap catch during new moon weak. The trap catches in the week after full moon and a week after new moon were not significantly different from each other. It was concluded that the light trap could also form a component of cotton IPM as it attracted 37.24 per cent of bollworms adults.

6.32
Problems and prospects of insect pest management in cotton in the Punjab

RAMESH ARORA, VIKAS JINDAL AND H. R. GARG
Punjab Agricultural University, Regional Research Station, Faridkot-151 203

Cotton is a premier cash crop which has contributed substantially to the economic development of the Punjab state. However, the productivity of the crop has declined from a peak of 607 kg/ha seed cotton in 1991-92 to a low of 171 kg/ha in 1998-99. Though the trend of declining productivity has been reversed during the last two years with seed cotton yield of 381 kg/ha during 2003-04, but it is still abysmally low as compared to China (1076 kg/ha), USA (732 kg/ha) and other major cotton growing countries.

Insect pests have always been a key factor responsible for low productivity of the crop in Punjab and elsewhere. But the pest problems have aggravated substantially during the last two decades. This has resulted in the phenomenon of pesticide treadmill. The insecticides constituted only about 2.2 per cent of the cost of cultivation during mid-1970s which increased to 13 per cent by mid-1990s. During 1970s, jassid, *Amrasca biguttula* (Ishida) and the pink bollworm, *Pectinophora gossypiella* (Saunders) were the only major pests. The American bollworm, *Helicoverpa armigera* (Hübner) and the whitefly, *Bemisia tabaci* (Gennadius) were elevated to the status of major pests during 1990s. The whitefly also emerged as a vector of cotton leaf curl virus, a new scourge of cotton which toegether with the American bollworm threatened to wipe out the crop from northern India. The tabacco caterpillar, *Spodoptera litura* Fabricius is another pest which has been increasing in severity on cotton during the last decade. Among the factors responsible for increasing outbreaks of pests in the state are:cultivation of a large number of susceptible and undescriptive cultivars with varied growth pattern; prolonged sowing period resulting in green and succulent foliage as well as floral bodies for a longer period; intensive culivation ; introudction of rice crop alongside cotton in the cotton zone; favourable hot and humid climate; excessive and indiscriminate use of irrigation, fertilizers and above all pesticides; poor spraying technology; poor adoption of non-chemical methods of pest mangementl; dependence on traders for inputs particularly seeds and insecticides.

If the productivity is to be increased to international standards, adoption of integrated pest management at the farmers level can no longer be delayed. Promising results have been obtained by different research workers with a number of IPM tactics in field trials in the state and elsewhere. The IPM module evaluated at the AICCIP Faridkot centre has given encouraging results. Weekly releases of egg parasitoid *Trichogramma chilonis* Ishii or sprays of *Bacillus thuringiensis* based biopesticides in combination with insecticides proved to effective for the management of bollworms. Similarly, alternate application of high potency neem-based insecticides led to effective management of whitefly. The pink and spotted bollworms could also be managed effectively with some neem-based insecticides. Among the cultural practices, early and synchronized sowing over the entire cotton-growing zone is expected to reduce the severity of bollworms and leaf curl virus. Wider-spacing as recommended for different plant types will not only reduce pest buildup but also facilitate efficient spraying. The destruction of alternate weed hosts of spotted bollworms and leaf curl virus is essential to reduce the incidence of these organisms.

Transgenic cotton containing the *Cry* 1 Ac gene from *Bacillus thuringiensis* is another option for reducing bollworm incidence which is likely to be available to the farmers in the near future. Some of the new insecticides also effectively control the American bollworm. But to extend the useful life of these chemicals, these have to be directed only against *H. armigera.* The use of these insecticides on alternate crops (chickpea, sunflower, tomato) where *H. armigera* is serious also needs to be discouraged. A critical factor in IPM is the easy availability of good quality seed of recommended varieties/hybrids. Farmers need to be discouraged from growing undescript cultivars and mixture. The IPM tactics need to be adopted on an area wide basis to derive full benefits from these measures and to demonstrate their effectiveness to the farmers. Lastly, it needs to be emphasized that IPM is a dynamic and knowledge intensive decision support system. Therefore, a better understanding of the cotton ecosystem will lead to improved pest management at lower costs to the farmers and the society in future.

6.33
Latest trends in cotton insect pest management

G. M. V. PRASADA RAO, K. SUDHAKAR AND P. RADHIKA
Acharya N. G. Ranga Agricultural University, Regional Agricultural Research Station, Nandyal-518 503

Insect pests of cotton cause significant crop losses. To prevent the losses, farming community resorts to application of pesticides. The consumption of pesticides in cotton is so much that it accounts for 55 to 60 per cent of total used in agriculture. This over dependence on synthetic chemicals in cotton pest management strategy resulted in frequent crop losses due to development of many fold resistance in major pests *viz; Helicoverpa armigera* and *Spodoptera litura,* resurgence of minor pests, elimination of beneficial insects, environmental pollution, pesticide residues in food chain and heath hazards. This adverse impact led to reorientation of plant protection strategies towards ecologically sound integrated pest management (IPM).

To avoid the above problems and to create sound agro-ecological base, the adoption of IPM is being advocated since 1980's. The efforts are in full swing to develop new technologies and also fine tuning of the existing technologies to suit various agro-eclological situations. All these efforts in research paved way to the development of new technologies. The latest ones which need all attention and adoption are: revitalizing seed treatment segment and highlighting the importance of seed treatment as sound IPM tool, commerical availability of bio-agents, stem application technique against sucking pests of cotton, development of new molecules which are effective against target pests even at low doses, dissemination of IRM strategies against important cotton pests, transgenic *Bt* cotton against major bollworms of cotton, etc. These are welcome trends. However, cotton insect pest mangement is information intensive and time sensitive, hence, sustained and long term efforts are needed to achieve desired results keeping in view of the emerging new pest problems.

6.34
Economically important Heteropterous bugs (Hemiptera) on cotton

SUCHETA AND K. S. KHOKHAR
CCS Haryana Agricultural University, Krishi Vigyan Kendra, Rohtak-124 001

Cotton is the main fibre crop in India. Gujarat, Haryana, Punjab and Rajasthan are the major cotton growing northern states. Several surveys were conducted during 1993-98 and 2002-03, for the collection of the heteropterous bugs associated with different crops including cotton under different agro-ecosystems of Haryana and adjoining states. It was observed that cotton crop harboured a large number of insects : some responsible for the low productivity and quality deterioration, while others serving as predators of several pest species. Different bug species occurred throughout the crop season. However, the present investiations were restricted to the pest and predatory species of Heteroptera (Hemiptera) associated with cotton. The bio-systematic studies on these bugs revealed that 16 species belonging to seven families qualified as pests and 13 species of six families as predators. The studies further indicated that the maximum number of species (8) injurious to cotton belonged to the family Pentatomidae *viz., Agonoscelis nubila* Stal, *Acrosternum* sp., *Bagrada hilaris* (Burm.), *Dolycoris indicus* Stal, *Eysarcoris guttiger* (Thumb.), *Menida labecula* Dist., *Nezara viridula* (Linn.) and *Piezodorus rubrofasciatus* (Fab.), followed by Pyrrhocoridae and Scutelleridae with 2 species each i. e. *Dysdercus cingulatus* (Fab.), *D. koenigii* (Fab.) and *Fitha ardens* Walk. and *Scutellera nobilis* (Fab.), and one species each of the families: Coreidae (*Clavigralla horrens* Dohra), Largidae (*Macrocheraia grandis* (Gray), Miridae (*Lygus sp*) and Oxycarenidae (*Oxycarenus hyalinipennis* Costa). The nymphs and adults of these bugs were observed sucking the sap from leaves, shoots and green bolls, besides a few species acting as cotton stainers and seed feeders, thus affecting the quality of cotton produce and oil contents of seeds. Further, nymphs and adults of predatory bugs were found sucking the body fluids of their prey species which constituted mainly lepidopterous caterpillars like *Helicoverpa armigera* (Hubn.), *Earias insulana* Boisd and *E. vittella* (Fab.) and heteropterous pests like *Dysdercus spp.* and *O. hyalinipennis.* Amongst the predatory bugs, the family Reduviidae dominated with seven species *viz., Acanthasipis flavipes* Stal, *A. quinquespinosa* (Fab.), *Coranus pallidus* Reuter, *Ectomocoris cordiger* Stal, *Oncocephalus annulipes* Stal, *Pirates affinis* Serville and *Rhynocoris marginatus* (Fab.), followed by Pentatomidae with 2 species i. e. *Andrallus spinidens* (Fab.) and *Eocanthecona furcellata* (Wolff) and one spcies each of the families: Anthocoridae (*Orius sp.*), Geocoridae (*Geocoris* sp.), Nabidae (*Nabis sp.*) and Pyrrhocoridae (*Antilochus coquebertii* (Fab.). Under laboratory conditions the mode of predation and predatory efficiency of *A. coquebertii* and *E. furcellata* against the above menioned caterpillars of Lepidoptera was recorded. The phenomenon of mimicry was also noticed amongst the feeding stages of *A. coquebertii* and *R. marginatus* with those of *Dysdercus spp.* Further, the aforesaid heteropterous species were illustrated and described alongwith the morphometrics of their important taxonomic and diagonstic characters. A key was also constructed fot their easy identification.

6.35
Development of an IPM module for summer rice fallow cotton

P. CHANDRAMANI, N. MURUGESAN AND N. SIVASAMY
Cotton Research Station, Tamil Nadu Agricultural University, Srivilliputtur-626 125

An IPM module comprosing of seed treatment with imidacloprid, basal neem cake application, *Trichoderma viride* application, neem oil drenching twice, one spraying for sucking insects and three spraying for bollworms was evaluated in comparison to farmers practice (three sprayings for sucking insects and six sprayings for bollworms). IPM module recorded minimum sucking insects population than that of farmers practice in the early phase. The percent reduction of 51.63, 81.72 and 46.06 in respect of leafhopper, aphid and thrips was realized in IPM module over farmers practice. Per cent reduction of *Earias sp.* (43.33), *Helicoverpa*

sp. (1.94) and *Pectinophora gossypiella* (29.12) was observed in IPM module. Raising intercrops in IPM module helped to conserve the natural enemies population. Non-judicious use of pesticides in farmers practice reduced spider and coccinellid population. There was 32.91 and 32.61 per cent increase in spider and coccinellid population in IPM module over farmers practice. Inclusion of various traps in IPM module played a role in monitoring the key insects.

6.36
Evaluation of integrated pest management tactics against *Amrasca devastans* (Distant) in cotton

N. MURUGESAN, A. KAVITHA, P. CHANDRAMANI AND N. SIVASAMY
Cotton Research Station, Tamil Nadu Agricultural University, Srivilliputtur-626 125

Field experiments on the integration of different pest management tactics *viz.,* resistant cultivar (KC 2), seed treatment, cropping system approach and need based application of insecticide against *Amrasca devastans* (Distant) in cotton revealed that KC 2 cotton grown from imidacloprid treated seeds (19 ml kg^{-1}), raised along with cluster bean (2:1) and sprayed with dimethoate (0.03%) based on ETL reduced leafhopper incidence by 86.32 per cent; increased plant height by 37.17 per cent; reduced bad *kapas* content by 37.77 per cent; and increased seed cotton yield by 125.88 per cent compared to the untreated LRA 5166. On the other hand, KC 2 grown from monocrotophos treated seeds (10 ml kg^{-1}), raised along with clusterbean (2:1) and sprayed with dimethoate (0.03%) based on ETL reduced leafhopper incidence by 79.49 per cent; increased plant height by 39.93 per cent; reduced bad *kapas* content by 42.73 per cent; and increased seed cotton yield by 129.76 per cent compared to the untreated LRA 5166.

6.37
Promotion of insecticide resistance management strategies in irrigated cotton escosystem in Punjab

A.K. DHAWAN, A N NARULA , TRIPAT KUMAR AND P. D. SHARMA
Department of Entomology, Punjab Agricutlural University,Ludhiana-141 004

Cotton pest scenario has changed considerably in Punjab during the last decade. Among sucking pests, whitefly (*Bemisia tabaci* Gennadius) has become dominant pest. Pink bollworm which was serious pest for cotton has almost been replaced by a polyphagous pest, *Helicoverapa armigera* (Hubner). The management strategies adopted by cotton growers are insecticides based. The number of sprays has increased from 4.5 in 1975 to 7.5 in 1990 and 20.7 in 2001. More than 360 per cent increase in number of sprays failed to reduce the losses due to pests and give economic returns. One of the main reasons for the insecticide failure is the development of insecticide resistance in *H. armigera* and *B. tabaci*. The indiscriminate use of synthetic pyrethroids alone and in combination has also resulted in resurgence of whitefly. The insecticides based integrated pest management (IPM) technology adopted by cotton growers is not based on principles of insecticide resistance management (IRM). During 2002 and 2003 crop seasons the IRM based IPM was promoted in 30 villages in cotton belt of Manasa, Bathinda and Ferozepur. The main components of four window based IRM strategy included the timely sowing of cotton crop, cultivation of varieties tolerant to early season sucking pest, judicious use of fertilizer and irrigation water, conservation of natural enemies and need based use of insecticides. The farmers were provided training on identification of pest and natural enemies, surveillance, concept of economic threshold, insecticide resistance and were encouraged to take decision on need based strategy. The selection of insecticides was based on pest complex with emphasis on conservation of natural enemies till early flowering phase. The strategies were designed to manage insecticide resistance in *H.armigera,* particularly to synthetic pyrethroids. The damage in shed fruiting bodies due to spotted bollworm was 9.2 and 5.6 per cent in IRM villages than in12.4 and 11.3 non IRM villages during 2002 and 2003 crop seasons, respectively. Similarly the damage by American bollworm in shed fruiting bodies was 7.7 and 11.6 and in project area against 23.1 and 17.4 and in non IRM villages during these years. The population of

predators was 32-75 percent higher in IRM adopted villages. The number of sprays decreased by 34.5 and 25.7 per cent resulting in 43.4 and to 20.5 reduction in cost of insecticide sprays in 2002 and 2003 crop season, respectively. The increase in seed cotton yield was marginal. The net gain (Rs/ha) to the IRM farmers over non IRM was 8017 and 10400 during these two years. Theses studies indicate that number of sprays can be further decreased by 10.0-18.7 per cent as indicated by supervised IRM experiments. The farmers still lack confidence in use of need based insecticides and like to adopt old strategy of spraying cotton crop without any surveillance and proper selection of insecticide at 3-5 day spray interval. Other major constraints included the delayed sowing of cotton crop due to unavailability of canal water. There were wide variation in time of sowing in three districts which indicated area specific IRM strategies. Another major constraint is the cultivation of cultivars with wide variation in susceptibility to pests and flowering pattern. More than 50 hybrids and varieties are cultivated with area less than 5 percent. The lack of proper identification and surveillance resulted in indiscriminate use of insecticides. More than 78.3 percent farmers did not follow the proper spray technology. These studies
indicated that the dissemination of IRM based IPM can result in overcoming the problem of indiscriminate use of insecticides, development of insecticides resistance which was responsible for cotton failure in the past.

6.38
Pattern of insecticide use for management of insect pests on cotton in Punjab

A. K. DHAWAN, A. M. NARULA , TRIPAT KUMAR, KAMALDEEP SINGH AND SUBASH SINGH
Department of Entomology, Punjab Agricultural University, Ludhiana-141 004

Cotton crop in north India is attacked by a number of pests from sowing to maturity. The management of these pests requires the judicious use of insecticides based on economic threshold levels. However, the cultivation of high yielding susceptible varieties under insecticide umbrella to get higher return resulted in excessive use of insecticide which increased from 6-7 in 1990 to 20-30 sprays by 2000. The indiscriminate use resulted in development of resistance to insecticides and resurgence of new pests. This insecticide treadmill resulted in increase in cost of pest management in cotton. During 2002 and 2003 crop season, study was carried out on the pattern of insecticides use in three cotton growing district of the Punjab state. In Mansa district, the number of sprays for sucking pests was 0.68 and 1.14 during 2002 and 2003 season, respectively. The use of carbamate and organochlorinated (OC) insecticide was negligible. Among organophosphate insecticides (OPs), monocrotophos and ethion/triazophos were dominant insecticides in 2002, while in 2003 triazophos/ethion were dominant insecticide. The synthetic pyrethroids (SPs) were used mostly in combination. Maximum sprays were in combination with triazophos/ethion being 4.6 and 3.7 in these two years, respectively. The sprays with indoxacarb/spinosad increased from 0.92 in 2002 to 1.75 in 2003. The total sprays were 14.31 and 13.77 in 2002 and 2003, respectively. The maximum sprays were during 111-140 days after sowing (DAS). In Bathinda district, the number of sprays for jassid control was 0.36 and 1.19 in 2002 and 2003 crop season, respectively. The sprays were negligible with carbamate and organochlorinated insecticides. Synthetic pyrethroids increased from 0.88 in 2002 to 1.25 in 2003 . Most of the SPs were used in combination with OPs, particularly with ethion and triazophos. The use of OP alone was higher in 2002 than in 2003. The sprays with new molecules, indoxacarb and spinosad, increased from 0.57 in 2002 to 1.86 in 2003. The total numbers of sprays were 17.41 in 2002 against 13.18 in 2003. The maximum sprays were during 111-140 DAS. In Ferozepur district, similar trend was observed for the management of cotton jassid as in other districts. The use of endosulphan was low and that of carbamate slightly more than in Mansa and Bathinda. The use of SP alone declined in from 0.64 in 2002 to 0.39 in 2003 . Most of the sprays were with combination of OP and SP. The dominant combination was SP + ethion/triazophos followed by SP + acephate/chlorpyriphos. The use of SP + ethion/triazophos was higher in 2003 (5.30 sprays) than in 2002 (2.28 spray).The sprays with new molecules, indoxacarb and spinosad increased from 1.32 in 2002 to 2.16 in 2003 . The pooled data for these two years indicated that number of sprays with imidacloprid /thiamethoxam increased from 0.55 in 2002 to 1.24 in 2003. The number of sprays with OC and carbamate remained low during these years. The sprays with SP alone remained to the same level during these years (0.73-0.7). Among OPs, the use of monocrotophos, acephate and chlorpyriphos declined in 2003. Triazophos/ethion +SP was the dominant combination; being used in 3.94 and

4.50 spays in these two years. The use of spinosad/indoxacarb was higher in 2003. These studies indicate decline in use of monocrotophos which was very toxic to natural enemies and most of the sprays were during early phase of crop when natural enemies were abundant. The use of OC and carbamate was low and needed to be increased to reduce dependence on SP alone or in combination. Among OPs, the use of quinalphos and profenophos which were very effective against bollworms needed to be encouraged. Chlorpyriphos use had declined due to the reddening of leaves with its use, particularly in crop which is under stress. Acephate is the molecule which has acceptance with farmers as it promotes vegetative growth and is also effective against American bollworm. The use of SP + triazophos/ ethion was exceptionally higher and repeated use was responsible for resurgence of whitefly and also development of resistance to American bollworm. The new molecules, spinosad and indoxacarb, proved very effective and their use will increase. This will also help in reduction in number of sprays as these were effective for longer period. Most of the sprays were done without proper monitoring. The number of sprays could be reduced to 8-10 without any significant reduction in seed cotton yield.

6.39
Latest trends in cotton insect pest management

G. M. V. PRASADA RAO, K. SUDHAKAR AND P. RADHIKA
ANGRAU, Regional Agricultural Research Station, Nandyal-518 503

Insect pests of cotton cause significant crop losses. To prevent the losses, farming community resorts to application of pesticides. The consumption of pesticides in cotton is so much that it accounts for 55 to 60 per cent of total consumption of pesticides in agriculture. This over dependence on synthetic chemicals in cotton pest management strategy has resulted in several problems like development of resistance in major pests *viz., Heleicoverpa armigera* and *Spodoptera litura,* resurgence of minor pests, elimination of beneficial insects, environmental pollution, pesticide residues in food, health hazards, etc.

To avoid the above problems and to create sound agro-ecological base, the adoption of integrated pest management (IPM) is being advocated since 1980's. The efforts are in full swing to develop new technologies and also fine tuning of the existing technologies to suit various agro-ecological situations. All these efforts in research have paved way to the development of new technologies. The latest ones which need all attention and adoption are: revitalizing seed treatment segment and highlighting the importance of seed treatment as sound IPM tool, commercial availability of bio-agents, stem application technique against sucking pests of cotton, development of new molecules which are effective against target pests even at low doses, dissemination of insecticide resistance management (IRM) strategies against important cotton pests, transgenic *Bt* cotton against major bollworms of cotton, etc. However, cotton insect pest management is information intensive and time sensitive, hence, sustained and long term efforts are needed to achieve desired results keeping in view of the emerging new pest problems.