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"Cotton Production Technologies in the Next Decade : Problems & Perspectives"
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at
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BOOK OF ABSTRACTS AND SOUVENIR

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PREFACE

Cotton is one of the most ancient and very important commercial crop of global importance with a significant role in Indian agriculture, industrial development, employment generation and improving the national economy. It is cultivated for domestic consumption and also exported in about 111 countries worldwide and hence called **"King of Fibres"** or **"White Gold"**. Millions of people depend on cotton cultivation, trade, transportation, ginning and processing for their livelihood. India is the only country in the world growing all the four cultivated species of cotton alongwith their hybrid combinations in the vast diverted agro-climatic situations. Cotton is basically cultivated for its fibre which is used as textile raw material. It is cultivated from Punjab in the north to Kanyakumari in the south and Assam in the east to Kutch (Gujarat) in the west.

India, the second largest producer, consumer as well as exporters of cotton next to China with 34 per cent of world area and 21 per cent of world production and continue to maintain the largest area under cotton. Within a span of fifteen years, the cotton production in the country has gone more than double with the increase of the productivity. The productivity of cotton has not made headway because of more than 70 per cent area is under rainfed cultivation and appearance of new diseases and insect pests in transgenic cotton. However, new emerging threats in terms of biotic and abiotic factors are to be understood properly and effective strategies need to be evolved for their proper redressal. The problems and prospects of *Bt* cottons in the country need to be put in a proper perspective. Therefore, there is an urgent need to properly understand the IPR issues in the best interest of farmers and scientists.

In order to maintain pace with the increased demand for the commodity, both in national and international market, it is imperative to give impetus for development of new cotton and fibre crops varieties and hybrids with appropriate cultivation technologies. Introduction of large number of private sector *Bt* cotton hybrids have brought a welcome change in recent times as far as production gains are concerned. However, to meet the ever increasing demand both in the domestic and international markets, an effective strategy needs to be developed.

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

We deem it a rare privilege to place on record our sincere gratitude to Dr. S. S. Siwah, Former Director of Research, CCS Haryana Agricultural University, Hisar and President, CRDA for his valuable guidance and directions in the general functioning of CRDA. We take this opportunity to thank all concerned and hope this **"Book of Abstracts and Souvenir"** will serves the purpose of cotton research workers for furthering the cause of cotton farmers.

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Editors
Dr. M. S. Chauhan
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Dr. Man Mohan
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CROP IMPROVEMENT, BIOTECHNOLOGY AND POST HARVEST TECHNOLOGY

1.1

AMMI stability analysis for seed cotton yield/plant in upland cotton (*Gossypium hirsutum* L.)

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Cotton popularly known as white gold is an important fibre crop plays a major role in the textile industry and world economy. The world uses more cotton than any other fibre. *Gossypium hirsutum* is the prime species of the cottons for its yield and quality traits. Heterosis is exploited in the form of hybrids in cotton. Among hybrids, intra hirsutum hybrids are popular in the cotton growing areas of the country. The development of hybrids by using diverse parents, evaluation of the cross combinations and identification of stable genotypes forms the important objectives in cotton breeding programmes. Further, sustainable cotton production requires identification and cultivation of stable cultivars. Genotype x environment (GxE) interactions are of major concern to plant breeders. The recent and best method among the stability models, AMMI analysis was effectively used for the identification of stable genotypes over locations. The present investigation was carried out with 45 *intra hirsutum* hybrids to study the genotype x environment interaction over three locations *viz.*,, Regional Agricultural Research Station, Lam, Guntur; Agricultural Research Station, Jangamaheswarapuram and Agricultural Research Station, Darsi of Andhra Pradesh, India, for seed cotton yield/ plant and the important seed cotton yield traits using Additive Main Effects and Multiplicative Interaction (AMMI) model. The AMMI model is a hybrid model involving both additive and multiplicative components of two way data structure. The AMMI model separates the additive variance and then applies principal component analysis to the interaction portion to extract a new set of co-ordinate axes which explain in more detail the interaction pattern, after fitting the genotype and environment main effects in the model. The IPCA scores of a genotype in the analysis are an indication of the stability of a genotype over environments. AMMI analysis provides a graphical representation (biplot) to summarize information on the main effects and interactions of both genotypes and environments simultaneously. Analysis of variance was significant for all the quantitative traits like sympodia/plant, bolls/plant and boll weight and environments and (G x E) components indicating the usefullness of AMMI analysis in identifying the stable genotypes. The analysis partitioned the total G x E component into IPCA1 and residual. Among the hybrids, BBGH - 3 × BBGH-26, BBGH - 33× BBGH- 1, BBGH - 3× BGH-94, BBGH-1× BGH -94, BBGH -3× GHL-8 and BBGH – 77× BBGH – 26 were found to be stable with high mean value than general mean (138.80 g) and zero I PCA score indicating stable performance across locations. The hybrids at Lam location

showed high mean values with high interaction effects indicating the adaptability to specific environments. The hybrids at Jangamaheswarapuram and Darsi recorded low mean values with low interaction effects. This, the study identified the stable genotypes for their effective exploitation.

1.2
Heterosis studies for seed cotton yield and yield contributing traits in *desi* cotton (*Gossypium arboreum* L.) over the enviornments

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Cotton is one of the most important fiber and cash crop of India and plays a dominant role in the industrial and agricultural economy of the country. The present study comprised of seven females (lines) and eight males (testers) with four standard checks thus making 56 F_1s using Line x Tester mating design. These lines, testers and hybrids along with four checks were sown during *kharif*, 2016 at three locations *viz.,,* Cotton Research Station, Nanded (L-1), Experimental farm of Department of Agricultural Botany, VNMKV, Parbhani (L-2) and Experimental farm, Agricultural Research Station, Badnapur (L-3). The observations recorded on days to 50 per cent flowering, days to 50 per cent boll bursting, plant height (cm), number of sympodia/plant, number of boll/plant, boll weight (g), seed cotton yield/plant (g), seed index (g), lint index (g), harvest index (%).

In pooled analysis of variance, crosses were found significant across the environments indicating the substantial variability among the crosses for all the characters. The environment x crosses component of variance was found significant for some characters indicating the influence of environment on the heterosis of these characters *viz.,* plant height, days to 50 per cent boll bursting, sympodia/plant, bolls/plant and days to maturity.Out of fifty six crosses, twenty six, fourteen and twenty crosses expressed significant standard heterosis over check PKVDH 1, PKV Suvarna and PA 255, respectively. While nine crosses recorded significant standard heterosis over standard check NACH 12. These nine crosses also exhibited highest heterobeltiosis. The cross PAIG 346 x JLA 794 possessed highest standard heterosis over PKVDH 1 (47.74%), PKV Suvarna (32.92 %), NACH 12 (27.52 %) and PA 255 (40.13 %) for seed cotton yield per plant. Whereas, it ranked second for heterobeltiosis (43.38%). This cross was found to be promising in all aspects like earliness parameters, high yield and fibre parameters across the locations. Another cross PAIG 346 x DWDa 1402 ranked second and third with respect to heterobeltiosis and standard heterosis for seed cotton yield per plant.Cross PA 809 x AKA 8 ranked first for heterobeltiosis and third for standard heterosis for seed cotton yield/plant. It showed highly significant heterobeltiosis and standard heterosis for

days to 50 per cent flowering, days to 50 per cent boll bursting, sympodia/plant, bolls/plant, harvest index and micronaire. Thus the present study on heterosis has clearly indicated that heterotic response for yield and its components results only in selected cross combinations indicating the predominant role of non-fixable inter allelic interactions. The crosses PAIG 346 x JLA 794, PAIG 346 x DWDa 1402, PA 809 x AKA 8, PA 785 x CNA 449, PAIG 346 x CNA 449 and PAIG 346 x HD 514 hold promise for further evaluation and commercial exploitation of heterosis for high yield.

1.3

Studies on genetic variability and association analysis for yield improvement in upland cotton (*Gossypium hirsutum* L.)

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Cotton is a crop of prosperity having a profound influence on men and matter. The assessment of genetic variability is prerequisite for organization of breeding programmes in any crop. The research work comprising of genetic variability, heritability and genetic advance as well as correlation and path analysis using fifty five genotypes of cotton (*Gossypium hirsutum* L.). The ex/iment was carried out at Cotton Research Station, Srivilliputtur, Tamil Nadu Agricultural University, Coimbatore, India during winter 2017 for 12 yield and fibre quality traits. The genotypic differences were significant for all the traits. The variability studies indicated that moderate estimate of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) was observed for monopodia / plant, bolls / plant, boll weight, fibre fineness and seed cotton yield whereas low PCV and GCV was observed for the remaining traits. Moderate to high heritability observed for most of the yield and fibre quality traits except sympodia / plant which has low heritability. Plant height, monopodia / plant, bolls / plant, boll weight, seed index, lint index, up/ half mean length, bundle strength, fibre fineness and seed cotton yield has moderate to high genetic advance as per cent of mean (GAM). Bolls / plant, fibre fineness and seed cotton yield shows high heritability coupled with high GAM indicating the preponderance of additive gene action in the inheritance of these traits. Hence selection is effective for inheritance of the traits. High heritability and low GAM was observed in ginning per centage which has non additive gene action therefore selection is not effective. The correlation study revealed that sympodia / plant, bolls / plant, ginning per centage, boll weight, lint index and bundle strength had a significant positive association with seed cotton yield. Path analysis revealed that bolls / plant, lint index, monopodia / plant, boll weight has maximum positive direct effect on seed cotton yield followed by bundle strength and fibre fineness.

1.4
Interspecific hybridization between *Gossypium hirsutum* and *Gossypium armourianum :* Morphological,cytological and molecular characterization of hybrids

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Interspecific triploid male sterile hybrids were developed between tetraploid *Gossypium hirsutum* species cv MCU 5 and CO 14 and the wild species *Gossypium armourianum.* The F_1 hybridity was confirmed through morphological, cytological andmolecular approaches. The F_1 hybrid was male sterile and the ploidy level was triploid. The pistil parents *viz.,*, MCU 5 and CO 14 had erect growth habit, cream petals, palmate leaves, green stem, thick and prominent leaf veins, embedded stigma, hairy stem and leaves. The variety MCU 5possess dense yellow anthers while dense cream anthers were obtained in CO 14. The pollen parent*Gossypium armourianum* has spreading growth habit, yellow petals, cordate leaves, reddish green stem, medium dense yellow anthers,thin leaf veins, protruded stigma and glabrous plant body. The growth habit, petal colour, leaf colour, leaf shape and size of interspecific F_1 hybrids were intermediate. Plant stem colour and hairiness, leaf pubescence, stigma protrution and anther colour of *Gossypium armourianum* were observed to express dominant characters and the F_1 hybrids fully resembled the pollen parent, *Gossypium armourianum*for these characters. Petal spot was observed in pollen parent and in F_1 triploid while the petal spot was not observed in pistil parents of MCU 5 and CO 14. Mitotic metaphase counts showed the pistil parents *viz.,*, MCU 5 and CO14 had 52 chromosomes, the pollen parent *Gossypium armourianum* had 26 chromosomes and the interspecific F_1 hybrid was with 39 chromosomes.Five markers unambiguously confirmed the hybrid status of interspecific hybrids out of 11 SSR markers polymorphic between parents. These F_1 hybrids may serve as pre breeding material for the development of jassid resistance cotton varieties owing to their female fertility.

1.5
Developing colour cotton variety with superior fibre quality traits

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Naturally, coloured cotton has a history of more than 5,000 years in India, Egypt and South America. Cotton fibre colours generally range from dark tan, brown, khaki, grey to green. Brown, grey and tan are due to tannin and phenolics present in vaculoles in the fibre lumen. Green fibre is due to the presence of caffeic acid and cinnamic acid present in wax layers interspersed with cellulose layers that envelope the cotton fibres. The flavonoids responsible for the lint colour are governed by genes at three loci, LCI, LC2, and LC3 which control more than one trait (pleiotropic). It is now known that dominant or incompletely dominant genes govern inheritance of natural lint colour. The green colour is governed by one gene while brown colour is controlled by two or more genes. It is also interesting that all the four cultivated species and 22 wild species possesses coloured cotton lint. Brown coloured lint is present *in G.aridum, G.armourianum, G.darwinii, G.mustelinum, G.anomalum, G.capitis-virdis, G.somalense, G.arboreum, G.stocksii, G.areysianum, G.incanum, G.australe, G.sturtianum* while other colours are present in rest of the species. The wild species *G.gossypioides, G.harknessii, G.herbaceum, G.longicalyx, G.robinsonii, G.sturtianum* var *nandewarense* possess greyish fibre. In the last few years, the demand of naturally coloured cotton has increased in some European countries which is estimated to be about 5-6 lakh bales/annum. The requirement of textile industries is for the varieties which possess fibre length 25-29 mm and fibre strength 20 – 23 g/tex. Identifying entries in color cotton falling within this range will motivate more farmers to grow color cotton.

A total of 13 colour cotton entries *viz.,* Lusiana brown, Algerian Brown, Nankeen Brown, Brymer Brown, Hirsutum Tashkant, Parbani American, Higgin Batham, Texas Green, Arkansas green, Red 5-7, Russian Brown, KCM Brown and MSH 53 are maintained in the Department of Cotton, CPBG, TNAU, Coimbatore. Colour cotton accessions are found to be poor in fibre quality triats. In order to improve the quality of the colour cotton, hybridization was made between colour cotton entries (thirteen colour cotton entries) as female parents with ELS cotton varieties *viz.,* MCU 5 and CO 14 as male parent during 2016-2017. Reciprocal crosses were also made. Twenty - six F_1 cross combinations were evaluated for yield, colour and quality triats during 2017-2018. The following sixteen F_1 cross combinations *viz.,* Lusiana Brown x CO 14, Algerian Brown x MCU 5, Red 5-7 x MCU 5, Parbani American x MCU 5, Algerian Brown x CO 14, Arkanas Green x MCU 5, Higgin Badam x MCU 5, Texas Green x MCU 5 and its reciprocals were selected based on the fibre quality triats and forwarded to F_2 generation for selecting the desirable single plants.

1.6
Developing early maturing compact plant type suitable for high density planting system in cotton

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Cotton is the world's most important natural textile fibre crop contributing significantly to economy directly and indirectly. It is considered as the king of fibre crops because it contributes more than 50 per cent of the raw material to the textile industry for preparation of the yarn that is woven into fabric for the production of clothing. At present, in India, entire cotton is picked manually which is labour intensive and is becoming expensive day by day. Machine picking is a viable alternative to manual picking which will not only minimize cost of cultivation, but also reduce the dependency on labour. However, the prerequisite for machine picking is the identification of cotton genotypes with short stature, earliness, compactness, short sympodia with synchronous boll opening. Under these circumstances, compact cotton genotypes which are ideally suited under varied cropping porgrammes and the need. Hence, one of the breeding priorities would be developing compact plant type which can be accommodated in high density planting that possess compact plant type characters *viz.,,* short plant stature, earliness, low or zero number of monopodia, higher number of short sympodia, better boll number and boll weight, uniform maturity, optimum leaf area, along with desirable yield and better fibre quality.

Among the twenty - four F_1 hybrids evaluated during 2017, based on the visual observations, three hybrids *viz.,,* TCH 1822 x CPD 1509, C-10-8 x RAHC 1017 and 343-1-1 x RAHC 1017 were found to be having compact plant types with higher ginning outturn of 40.1, 38.78 and 36.84 per cent, respectively. The cross combination C-10-8 x RAHC 1017 was also found to have superior 2.5 per cent span length (32.5 mm) and fibre strength (26.6 g/tex). These hybrids were forwarded to F_2 generation for further evaluation of compact plant types with superior fibre quality parameters. The cross combination TCH 1926 x RAHC 1017 was also found to be possess compact plants with very strong fibre strength (27.5 g/tex). The cross combination Anjali x RAHC 1017 also had semi-compact plants with 2.5 per cent span length of 31.5mm and fibre strength of 26.3 g/tex. The cross combinations TCH 1822 x RAHC 1017 and TCH 1822 x CPD 1509 recorded higher boll weight of 5.2g. These hybrid combinations showed compactness with higher yield with good fibre quality parameters. Therefore, having a follow up of these hybrids would result in identifying segregants with compactness and high single plant yield in subsequent generations.

1.7
Developing extra long staple and long staple cotton genotypes with high ginning outturn

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Cotton is the leading natural fibre crop of the world. In India long and extra long staple cotton contributes 64.54 per cent of total cotton mill consumption improvements in textile processing, particularly advances in spinning technology. Tamil Nadu is a pioneering in the development and cultivation of long and extra long staple cotton in the country. Release of first extra long staple premium *Gossypium hirsutum* variety MCU 5 in 1969 is a distinct mile stone in cotton research, the stability and adaptability of this variety spanning across southern states. Another Cotton variety CO14 released from TNAU during 2016 is an extra long staple cotton having > 35.0 mm of 2.5 per cent span length. New high speed spinning systems like vortex spinning demand fibres of highest quality for trouble free processing. The spinning mills also import significant quantity of long staple and extra long staple varieties. Most of the imports are Extra long staple (ELS) cotton from the U.S Egypt and West Africa. The quality of fibre produced is also of major concern. Moreover, the price of cotton is mainly determined on the fibre quality and spinning capacity. Since the demand for long and extra long staple cotton with good strength is high, it is considered as current requirement in cotton improvement. Improvement of 1 per cent in GOT will considerably increase the lint yield. Hence, it is need to develop cotton genotypes with extra long staple fibre categories with high ginning outturn.

During Winter 2017, eighteen F_1 hybrids were raised with two replication in RBD. Among eighteen F_1 hybrids, three hybrids *viz.,* SVPR 3 x DSC 1501, GSHV 171 x BGDS 1055 and SVPR 3 x RB 602 recorded higher ginning outturn of 39.8, 38.4 and 37.4 per cent, respectively. The hybrid GSHV 171 x CCH15-1 was found to have superior fibre strength (22.3 g/tex). In addition, forty F_1 hybrids along fourteen parents were also raised during Winter 2017 in non replicated trial for evaluation of GOT per cent with superior fibre quality. The hybrids *viz.,*, Anjali x DSC 1501 and TCH 1822 x LHDP-1 were found to have higher ginning outturn (>40 %). The culture TCH 1828 recorded the highest span length of 33.8 mm and bundle strength of 27.9 g/tex followed by TCH 1837 (span length of 30.8 mm ; bundle strength of 21.1 g/tex) in MLT 2017-2018 and this culture also proposed for ART during 2019-2020. These hybrid combinations showed higher ginning outturn with superior fibre quality parameters. Therefore, these hybrids would result in identifying segregants with extra long staple with high ginning outturn in further generations.

1.8

Heterosis studies in GMS based diploid cotton hybrids (*Gossypium arboreum* L) under rainfed conditions

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The present studies are undertaken to estimate heterosis with an objective of exploring possibilities of its commercial utilization under rainfed conditions. The experimental material comprised of fifty four hybrids along with one standard check hybrid PKV-Suvarna. The trial was conducted at Oilseeds Research Station, Mamurabad farm, Jalgaon. Observations were recorded for characters namely seed cotton yield (kg/ha),Lint yield (kg/ha), bolls/plant, average boll weight (g) and ginning percentage. The standard heterosis was calculated over check hybrid PKV-Suvarna. Marked economic heterosis was observed for most of the characters studied . Among all the hybrids the maximum heterosis for seed cotton yield was recorded by hybrid RHAH-1036(35.11%), lint kg/ha and bolls / plant was also recorded by same hybrid in the tune of 32.81 and 21.43 per cent, respectively, for average boll weight the maximum heterosis is recorded by hybrid RHAH-1047(16.67%), Very low amount of heterosis was observed for ginning percentage, the hybrid RHAH-1034(1.32%)given positive and highest heterosis as compare to standard check. There are several diploid hybrids and varieties under cultivation; this indicates there are much more scope of development of hybrids in diploid cotton and efforts are being taken through this study.

1.9

Heterosis studies in CMS based and conventional hybrids in cotton (*Gossypium hirsutum*)

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Cotton is one of the most important fiber and cash crop of India and plays a dominant role in the industrial and agricultural economy of the country. It provides the basic raw material (cotton fibre) to cotton textile industry. Cotton in India provides direct livelihood to 6 million farmers and about 40 -50 million people are employed in cotton trade and its processing. Sixty crosses with thirteen parents and three checks *viz.,,* PKV-Hy-4, NHH-206 and NHH- 44 were grown in Randomized Block Design with two replications. The results showed thatin CMS set of crosses better parent heterosis for seed cotton yield/plant ranged from 195.47 (CAK 53A x AKH-07R) to -42.33 (SRT-1A x R-23). Crosses CAK 53 A x AKH-07 R and SRT-1A x AKH-07 R showed the highest significant and positive better parent heterosis where as in conventional crosses, it was ranged from 160.50 (SRT-1B x AKH-07R) to -32.56 (CAK-23B x R-42-8). Crosses SRT-1B x AKH-07 R and CAK 53B x AKH-07R showed the highest significant and positive better parent heterosis. In two methods, the best heterotic crosses were CAK 53 x AKH-07R and SRT-1 x AKH-07R.

1.10

Heterosis and combining ability estimates for seed cotton yield components in line x tester crosses of transgenic upland cotton (*Gossypium hirsutum* L.) introgressed with BGII (*cry1Ac and cry2Ab2*-Mon 15985 event) lines

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Hybrid transgenic cotton is one of the most accepted form of cultivar by the farmers in India. Combining ability of parental lines and heterosis patterns provide important links in development of high yielding hybrids. A total of 105 hybrids derived (line x tester mating fashion) from 15 BGII showed significant differences among lines, testers and hybrids for yield and yield components indicating the presence of diverse genetic variability except days to flowering and days to fifty percentflowering.

Among the parents IAC7-15 exhibited a significant high GCA for seed cotton yield, days to firstflowering, days to fifty per cent flowering, plant height, sympodia , bolls and ginning outturn and whereas IAC7-1 for seed index (g), IAC7-8 for days tofirst flowering and monopodia, IAC7-15 for days to fifty percent flowering, IAC7-6 for plant height (cm), sympodia/plant and bolls/plant, IAC7-11 for bollweight (g), IAC7-12 for seed cotton yield(kg/ha) and seed index(g) and IAC7-19 for ginning outturn with high GCA was observed. The significant SCA effects were recorded for seed cottonyield in the cross combinations IAC7-15 X IAC-17, IAC7-11 X IAC7-18, IAC7-13 X IAC7-20,IAC7-3 X IAC7-17 and IAC7-12 X IAC7-17. The cross combination involvingIAC7-17 and IAC7-18 parents recorded high SCA effects for yield and its contributing characters.So these can be used for hybrid development program. The GCA variance was positive and dominance variance was negative reflecting the heterosis was more due to additive effects.

1.11
Heterotic studies in diploid cotton (*Gossypium arboreum* L,) under rainfed conditions

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The investigation was undertaken to estimate heterosis with an objective of exploring possibilities of its commercial utilization under rainfed conditions. The experimental material comprised of 10 Crosses along with one standard hybrid check (PKV-Dh-1) and grown at Mahatma Phule Krishi Vidyapeeth, Oilseeds Research Station, Mamurabad Farm, Jalgaon in randomized block design with 2 replications. Observations were recorded for characters' namely seed cotton yield(kg/ha), bolls/plant, average boll weight(g). The standard heterosis was calculated over standard hybrid check (PKV-Dh-1). Marked economic heterosis was observed for most of the characters studied. Among all the cross combinations the maximum heterosis for seed cotton yield of AKA-2004-29 x JLA-794(50.43%), highest heterosis for bolls/plant was observed in three crosses *viz.,* AKA-7 x JLA-0614, JLA-1110 x JLA-505, and PA-402 x JLA-505 in the tune of 26.87 per cent. for average boll weight AKA-2004-29 x JLA-794 (15.28%), The yield levels obtained in all the crosses and hybrid check are very low due to adverse environment during the season, however the heterosis obtained are positive and highest as compare to check hybrid. The cross combination AKA-2004-29 x JLA-794 recorded highest and positive heterosis for seed cotton yield inspite of low bolls/plant, however this cross found superior for highest average boll weight and it reflected in high seed cotton yield and high heterosis for seed cotton yield and average boll weight and this cross combination may be use for further hybrid development programme. Wherever cross combination involving JLA-794 and JLA-0614 as a male parent, recorded significant positive heterosis for most of the yield contributing characters.

Thus, the male parent JLA-794 and JLA-0614 may be used for exploitation of heterosis under rain fed conditions. There are several diploid hybrids and varieties under cultivation,this indicates there are much more scope of development of hybrids in diploid cotton and efforts are being taken through this study.

1.12
Studies on heterosis and combining ability analysis in upland cotton (*Gossypium hirsutum* L.)

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Thirty two hybrids of *G. hirsutum* cotton were fashioned in line x tester design using four lines and eight testers with a view to estimate heterosis and combining ability in cotton. The experimental material comprised of twelve parents, their thirty two crosses and two standard checks G Cot Hy 10 and G Cot Hy 12. A complete set of forty six genotypes was planted in randomized block design in three replications at the Main Cotton Research Station, NAU, Surat during *kharif* 2014-2015. The parents *viz.,* GSHV 171, NDLH 1928 and GISV 267 exhibited higher seed cotton yield per plant. Significant and desired directional heterosis was observed for majority of the yield attributing traits. The highest standard heterosis over both the standard checks as well as the higher heterobeltiosis for seed cotton yield/plant was recorded by the cross GISV 267 x NDLH 1928. High heterosis for seed cotton yield/plant in this hybrid was due to positive heterotic response by other yield attributing traits. Combining ability analysis revealed significant and positive variances due to general combining ability ($ó^2$GCA) for all characters except sympodia/plant which revealed the importance of additive gene action in inheritance of these characters. Similarly, variances due to specific combining ability ($ó^2$SCA) were observed significant for all the characters except lint index and 2.5 per cent span length which showed the role of non-additive gene action in inheritance of these traits. Majority of the characters manifested less than one $ó^2$GCA / $ó^2$SCA ratio indicated that non-additive effects, epistasis and/or dominance played a more significant role than additive effects for inheritance of these characters.

1.13
Need for quality compact cotton genotypes

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Cotton is the most important commercial crop in India and it plays a vital role in national economy of our country sustaining millions of people directly or indirectly.In the raw material consumption basket of the Indian textile industry, the proportion of cotton is around 59 per cent (Ministry of textiles, GoI). Even though synthetic fibres possess greater advantages in textile industries the thirst for cotton has never ceased so far. The fullest yield potential of the standing crop has not been exploited due to hurdles the crop faces from the environment some way or other. Due to biotic and abiotic stresses the optimum plant population is hardly maintained till harvest. Compact genotypes of cotton could find solution for this problem wherein manipulating plant structure can accommodate more plants/ha compensating the yield loss in later stages. Compact genotypes retain high percentage of total bolls in first sympodial branch with better light interception, efficient leaf area development, early canopy closure which shades out all weeds and reduce competitiveness.

As yield and quality never goes hand in hand due to negative correlation, compact genotypes which are marching towards the yield plateau needs due care in fibre quality aspects too. Therefore, research directed towards balancing yield and quality in compact cotton genotypes is the need of an hour. For which crosses have been attempted with five popular varieties with good fibre quality as male parents and eight compact linesand forty hybrids were synthesized. The hybrids are being evaluated during this season with an objective of recovering good hybrids coupling the above-mentioned ideas.

1.14

Association analysis and genetic variability studies for seed cotton yield and fiber quality improvement in intra specific crosses of upland cotton (*Gossypium hirsutum* L.)

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The experimental work comprising of sixty seven genotypes of upland cotton (*Gossypium hirsutum* L.) was carried out during winter 2017 at Cotton Research Station, Srivilliputtur, Tamil Nadu Agricultural University, Coimbatore, India to estimate the genetic variability, heritability and genetic advance as well as correlation and path analysis studies for thirteen traits including yield contributing and fibre quality traits. The genotypic differences were significant for all the traits. The variability studies indicated that high estimate of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were observed for seed cotton yield / plant, monopodia / plant and bolls / plant. Moderate phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were observed for seed index and fibre fineness. High heritability observed for monopodia / plant, sympodia / plant, bolls / plant, seed index, ginning /centage, 2.5 per cent span length, uniformity ratio, bundle strength, fibre fineness and seed cotton yield / plant. Number of monopodia / plant, bolls / plant, fibre fineness and seed cotton yield / plant shows high heritability coupled with high genetic advance over mean indicating the preponderance of additive gene action in the inheritance of these traits. The correlation study revealed that plant height, monopodia / plant, sympodia / plant, bolls / plant and ginning percentage had a significant positive association with seed cotton yield / plant. Path analysis revealed that bolls / plant has maximum positive direct effect on seed cotton yield / plant followed by plant height and 2.5 per cent span length.

1.15

Studies of genetic parameters for seed cotton yield, yield contributing and fibre quality characters in *desi* cotton (*Gossypium arboreum* L.)

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In the present investigation39 different elite genotypes of *desi* cotton along with three checks *viz.,* AKA-7, PA-08 and JLA-794 were studied to observe genetic variability, heritability and genetic advance for fifteen yield contributing and fibre quality characters.All these material were grown in randomized block design with two replications during *kharif* 2018 at Cotton Research Station, Mahboob Baugh Farm, V.N.M.K.V., Parbhani. Observations were recorded on ten yield and yield contributing characters *viz.,* days to 50 per cent flowering, days to 50 per cent boll bursting, plant height, sympodia / plant, bolls / plant, boll weight, seed index, lint index, harvest index, seed cotton yield / plant and five fiber quality characters *viz.,* ginning per cent, upper half mean length, fiberstrength, micronnaire and uniformity ratio. The data were collected and analysed for genotypic and phenotypic coefficient of variation, heritability, expected genetic advance.

The analysis of variance indicated that sufficient variability was present in the material for all the characters.A wide range of variation was found for almost all the characters. The high GCV and PCV were observed for boll / plant, seed cotton yield / plant, sympodia / plant, lint index and plant height.The phenotypic coefficient of variation (PCV) which measures the total variation was found to be greater than genotypic coefficient of variation (GCV).In the experiment all the characters showed very small difference between GCV and respective PCV, indicated that all the characters were least affected by environment.High heritability estimates coupled with high expected genetic advance were observed for the characters boll / plant, seed cotton yield / plant, sympodia / plant,, lint index ,plant height and micronaireindicating the presence of additive gene action and phenotypic selection may be more fruitful and effective for desired genetic improvement.The lines, GAU 259 (45.50 g), FDK 259(44.40g), RG 690 (42.00g) SV 385 (41.45g) , and JLA505 (40.75g) showed higher seed cotton yield / plant over all three checks *viz.,*, AKA-7 (27.10g), PA-08 (26.30 g) and JLA-794 (31.55g) .The genotypes CISA-6-123,PAIG 370,ANGAS 1302 and PA 08 showed superiority for fiber quality traits.

1.16
G.Cot.Hy-12 BG II - A high yielding hybrid for irrigated and rainfed ecosystem of Gujarat

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The hybrid G.Cot.Hy-12 (BG-II) was field tested at Surat, Junagadh and Talod in irrigated condition and at Bharuch and Dhandhuka in rainfed condition. Under irrigated condition, the hybrid G.Cot.Hy-12 (BG-II) gave significantly higher yield than its non *Bt* counterpart and 13.5 per cent higher yield as compared to zonal *Bt* check RCH-2 (BG-II) in pooled analysis. In rainfed conditions, hybrid recorded 18.1 per cent increased yield over its non *Bt* counterpart and 6.0 per cent increased yield over RCH-2 (BG-II) in pooled analysis. Overall G.Cot.Hy-12 (BG-II) showed its superiority in yield (2115 kg/ha) over its non *Bt* counterpart by 46.6 per cent and RCH-2 (BG-II) by 11.1 per cent. Further, the mean *Cry1Ac* protein of 9.14 ug/g in leaf , 3.49 ug/g in square, 4.96 ug/g in boll; and *Cry2Ab* protein of 621.21 ug/g in leaf, 446.43 ug/g in square and 392.83 ug/g in boll was recorded. The hybrid had boll size (4.4 g) with good opening and stay green character. It recorded staple length of 28.1 mm with good uniformity (47), average fineness (4.2 mv), medium fibre strength (21.7 g/tex) and good maturity (0.84) comparable to its non *Bt* counterpart. The performance of G.Cot.Hy-12 (BG-II) against all three intended bollworms was negligible and comparable to *Bt* check, while above ETL in non *Bt* check. The hybrid showed below ETL population of major sucking pests similar to *Bt* check and non *Bt* counterpart. It was found moderately resistant to bacterial leaf blight and *Alternaria* leaf spot disease and free from grey mildew. The hybrid was recommended for commercial cultivation by EBAM of GEAC, New Delhi.

1.17

Multivariate analysis in F_2 population of upland cotton for yield and fibre quality traits with compact ideotype

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The present investigation was accomplished in F_2 population of cross C12-2 x TCH 1705-250. The segregants were grouped into compact, semi compact and spreading type, since the parents are C12-2 (compact) and TCH 1705-250 (open type). This study was undergone during *kharif*, 2015 in Department of cotton, TNAU, coimbatore to identify superior transgressive segregants for different traits through multivariate analysis with compact ideotype.

Transgressive segregants was identified for single plant yield in two spreading type (95.48, 84.99), one semicompact (74.26) and one compact type (63.56). Two transgressive segregants in semi compact type (32.6mm, 31.2mm), two in spreading type (31.4mm, 31.2mm) and one in compact type (31.1mm) for 2.5 per cent span length was identified.

Significant and positive correlation was observed for single plant yield with fibre fineness, boll weight, bolls/plant, sympodia/plant- and plant height. Hence selection for these traits will help in selecting segregants with high seed cotton yield.

Through Biplot analysis from principal component analysis genotypes were grouped based on yield and fibre quality. The genotypes with more PCA1 and PCA 2 were identified as genotype with high yield and fibre quality traits

Inheritance of compactness followed 1 compact: 4 semicompact : 3spreading. This ratio didn't follow any Mendelian inheritance, indicates to increase - number of segregants in the study population (>191). Linkage, epistasis, apomixsis, pleotrophis effect may also be the reason to deviate from Mendelian ratio. Trangressive segregants identified with compact type can be forwarded to next generation and can be used for high density planting

1.18
Evaluation of *Gossypium hirsutum* germplasm accessions for yield and fiber quality traits

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Cotton is a natural fibre and known as the **"King of Fibres"** continues to be predominant fibre in the textile industries worldwide. The extensive genetic variation present in the genus *Gossypium* is distributed among 50 species, of which 4 are cultivated cotton *G. hirsutum* (American cotton), *G. barbadense* (Egyptian cotton), *G. arboretum* (Karunkanni cotton) and *G. herbaceum* (Uppam cotton).Knowledge of genetic diversity and relationships among breeding materials is essential to the plant breeder for improving this crop. Germplasm evaluation refers to the agronomic description of the material in a gene bank, for traits that are generally important to breeders in crop improvement. Main aim of evaluation is to reveal potentially useful variability for further use in genetic enhancement of crops. Fiber quality variability among the genotypes will also help in discriminating the genotypes which possesses good quality and yield.

The present investigation was carried out during *winter* 2017 at Department of Cotton, Tamil Nadu Agricultural University, Coimbatore. About 200 *Gossypium hirsutum* germplasm accessions were evaluated and attempts were made to identify accessions with good fibre quality and single plant yield. The investigation was carried out with the objective of evaluation of *Gossypium hirsutum* germplasm accessions based on their *per se* performance in the field. A total of 13 characters which include yield and fibre quality were recorded at the time of harvest stage for all the 200 accessions. Many germplasm accessions showed variation for most of the yield components and fibre quality triats. The accession with highest seed yield was found to be ISC 34 (200 g). The other accessions with good seed cotton yield were CB 2482 (195 g), Bar- NT- 43/37 (190 g), Sel-40-1 (190 g), 7727 (182.5 g), Stone ville-5B (175), GRS-60/1-Bar-B-MB 59-1 (165), GRS-60/2 UAMB-59/1 (165), ISC.35 (165) and Bar 7/2-1 (155). The monopodial vegetative branches were completely absent in B-57-960 and GRS-60/1-Bar-B-MB 59-1.Among 200 genotypes, five germplasms had shown excellent fibre strength and 2.5 per cent span length *viz.,*, Wuanza local, A-7262, A-619, PK.189-D and CP 25/1. These are the best genotypes that can be used to produce hybrids or varieties with high yield along with high fibre quality.

1.19
Identification of cotton hybrids through PCR based molecular markers

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Parentage of F1 hybrids of cotton *viz.,*, Hybrid 4 (G-67 x American nectariless), G.Cot.Hy-6 (G.Cot.100 x G.Cot.10), G.Cot.Hy-8 (G.Cot.10 x Surat dwarf), G.Cot.Hy-10 (BC-68-2 x LRA-5166) and G.Cot.Hy-12 (G.Cot.16 x 76-IH-20) were verified using random amplified polymorphic DNA (RAPD), Inter simple sequence repeat (ISSR) and microsattelite (SSR) assays. Out of 84 primers surveyed, ten RAPD random primers (RPI1, RPI6, RPI7, RPI9, RPI11, RPI14, RPI17, RPI18, RPI22, RPI24), two ISSRs (ISSR1 and ISSR9) and 3 SSR primers (SRT86, SRT91 and SRT97), were found to be polymorphic between parents of the hybrids studied. Further, two random decamers were found heteroallelic (RPI14 and RPI22). These highly informative primers not only differentiated the parent genotypes but also confirmed true F1 hybrids. Primer RPI14 amplified two polymorphic loci designated as RPI14_350 (G.Cot.10) and RPI14_1000 (Surat dwarf) in G.Cot.Hy-8, while primer RPI22 amplified RPI22_1000 (G-67) and RPI22_700 (American nectariless) alleles in G.Cot.Hy-4, respectively. Markers *viz.,* RPI1, RPI6, RPI9, RPI11, RPI14, RPI17, RPI24, ISSR1, ISSR9, SRT86 and SRT97 produced female specific amplicons, while markers *viz.,* RPI7, RPI11, RPI14, RPI18, RPI22 and SRT91 produced male specific amplicons in the hybrids. Further, the combination of SRT86_620 and SRT91_580 marker can be used for identification of true hybrid, G.Cot.Hy-10. Our findings revealed that RAPD, ISSR and SSR markers are useful in parentage confirmation and true hybrid identification, further the markers identified would enhance efficiency of cotton breeding programs.

1.20
Evaluation of cotton genotypes for seed oil, protein and gossypol contents

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The seeds of 34 genotypes were analyzed for oil, gossypol and protein content. Experiment was conducted at Main Cotton Research Station, Navsari Agriculture University, Surat during 2017-2018. The results showed significant variations amongst the genotypes. Significantly higher oil content was observed in cotton genotypes ARBH 1701 (18.12 per cent) followed by PBH 116 (18.04 per cent) and RAH 0603 (18.00 per cent). Gossypol content ranges from 37.47 to 156.49 (mg/100g of tissue) in different entries. Lowest gossypol content was observed in CPD 1701 (37.47 mg/100g of tissue) followed by F 2662 and GISV 319 (39.3726 mg/100g of tissue) and PBH 139 (44.47 mg/100g of tissue). Higher gossypol content was found in PBH 116 and RB 607 (156.49 and 153.26 mg/100g of tissue) respectively. Highest protein content was observed in SHJ 23 (23.72 mg/g of tissue) which was followed by HS 300 and F 2596 (23.08 and 21.94 mg/g of tissue) respectively.

1.21
PKV Hy 2 BG II: Successfully commercialized first *Bt* cotton hybrid of public sector in Maharashtra

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In current decade, India is maintaining position of leading in cotton acreage in the world, China leading in terms of cotton production and United States is ahead in export of cotton. On the productivity front Australia is leading with average yield of 1814 kg lint/ha, followed by China (1726 kg/ha) and Brazil (1636 kg/ha) and India is way behind at 507 kg lint/ha. After successful launch of first commercial cotton hybrid H_4 in 1970 in India, Dr. PDKV, Akola released cotton hybrid PKV Hy 2 in 1981 for Maharashtra State. This hybrid is having high yield potential and suitable for rainfed

condition and due to dense hairy leaves; it is tolerant to major sucking pests. This hybrid was not only popular amongst farmers of Maharashtra but it also covered major cotton growing area of central zone very soon after its release due to its wider adaptability. But after introduction of *Bt* cotton technology in 2002, farmers started growing *Bt* cotton hybrids and area under PKV Hy 2 was shrunken and replaced by *Bt* cotton hybrids. But farmers could not forget the performance of PKV Hy 2 and they were continuously demanding *Bt* version of PKV Hy 2 to the University officials. So, looking towards the demand of farmers, Dr. PDKV, Akola and MSSCL, Akola signed a MoU in 2013-14 to convert PKV Hy 2 in *Bt* version. Accordingly, a well defined BG II gene introgression programme in parents of PKV Hy 2 was initiated by University and MSSCL. After completion of the introgression work, a multi location trial to evaluate the performance of PKV Hy 2 BG II was conducted at Akola, Nanded and Jalgaon during *kharif*, 2016. After generating sufficient data, release proposal of PKV Hy 2 BG II was submitted to Department of Agriculture and Cooperation for getting clearance from DAC and State Agricultural Department, PKV Hy 2 BG II was released for its cultivation in Maharashtra during 2017-2018. Few large scale demonstrations were grown on research stations of University and on farmers' field. Large scale seed production of PKV Hy 2 BG II was undertaken during 2018-2019. About 25000 seed packets were sold during *kharif*, 2019. Farmers are showing satisfaction with performance of PKV Hy 2 BG II.

1.22
Transfer of CLCuD resistance in *Gossypium hirsutum* L.

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Cotton leaf curl disease is among the most devastating natural calamity that inflicted huge losses to cotton crop productivity especially in north zone of India during the last 20 years. This disease is caused by whitefly-transmitted geminiviruses. The control of cotton leaf curl disease has been a difficult task, therefore, to ensure the cotton production in a sustainable manner, development of resistant varieties/hybrids is the only consistent and economical method of CLCuD management. Majority of *Bt* hybrids being cultivated in northern India are susceptible to CLCuD. As there is no resistance source available against this virus within *Gossypium hirsutum* species, therefore Punjab Agricultural University, Regional Research Station, Faridkot has made an attempt to transfer CLCuD resistance in *Gossypium hirsutum* by using three donors namely, *Gossypium armourianum, Gossypium arboreum* and Synthetic Allotetraploid. American genotypes *viz.,* F 1861, F 2228 and F2164 were

crossed to these donors. Progenies showed CLCuD resistance had been selected and further backcrossed to parental American genotypes for improvement in agronomic performance. Presently BC_3F_1 to BC_5F_1 progenies showing CLCuD resistance are available. Performance of these progenies is being improved through backcrossing. Subsequently, improved progenies showing CLCuD resistance can be release as resistant varieties.

1.23

Study of heterosis for seed cotton yield, yield contributing and fibre quality traits in *desi* cotton (*Gossypium arboreum* L.)

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The *desi* or diploid varieties are still preferred in the low rainfall areas because of their inbuilt tolerant to pests and diseases, drought tolerance and suitability under rainfall conditions, which evoked the interest for developing superior hybrids in Asiatic cotton.The present investigation was undertaken to estimate heterosis, heterobeltiosis and standard heterosis of the crosses.It was sought through a line x tester mating design involving 5 diverse female lines and 6 male parents. The resulting 30 crosses were grown in *kharif*, 2017 along with 11 parents and 3 checks at Cotton Research Station, Mahboob Baugh Farm, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The experiment was laid in randomized block design with two replications. Observations were recorded on fourteen characters *viz.,,* days to 50 per cent flowering, sympodia/plant, bolls/plant, boll weight (g), plant height (cm), day to maturity, seed cotton yield/plant (g), lint index, seed index (g), ginning outturn (%), 2.5 per cent span length (mm), fibre fineness/micronaire value (g/inch), fibre strength (g/tex), and uniformity ratio (%).Estimation of heterosis was done over mid parent, better parent and three standard checks *viz.,,* PKVDH 1, PKV Suvarna and NACH 12.

Analysis of variance carried out for fourteen characters, showed significant treatment differences for all characters studied. It indicated presence of substantial genetic variability among the selected parental lines. The magnitude of heterosis, heterobeltiosis and standard heterosis for all the characters in the present study was highly appreciable. Among all the characters, the magnitude of mid parent heterosis for plant height was 62.27 per cent in the cross PA 828 x PA 08. Better parent heterosis was highest 56.91 per cent in the PA 828 x PA 08. Whereas, standard heterosis was highest for seed cotton yield/plant to the extent of 34.11 per cent in the cross PA 828 x PA 08 over standard check PKV Suvarna. Out of thirty crosses, the crosses showed highest and desirable

significant standard heterosis for various traits *viz.,* cross PA 848 x Phuledhanwantary for bolls/ plant for seed cotton yield / plant, for bolls/plant and lint index; PAIG 77 x Phuledhanwantary for sympodia / plant; PA 828 x AKA 7 for days to 50 per cent flowering; PA 740 x RAC 024 for boll weight; PA 828 x PA 08 for plant height; PA 848 x PA 08 for days to maturity; PA 828 x AKA 7 for 2.5 per cent span length; PA 828 x RAC 024 for fibre fineness (micronaire); PA 740 x RAC 024 for fibre strength; and PA 760 x RAC 024 for ginning outturn were found most superior cross combinations for respective characters.

1.24

Study of combining ability for seed cotton yield, yield contributing and fibre quality traits in *desi* cotton (*Gossypium arboreum* L.)

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The present investigation was undertaken to estimate combining ability of parents and hybrids. It was sought through a line x tester mating design involving 5 diverse female lines and 6 male parents. The resulting 30 crosses were grown in *kharif*, 2017 along with 11 parents and 3 checks at Cotton Research Station, Mahboob Baugh Farm, VasantraoNaikMarathwadaKrishiVidyapeeth, Parbhani. The experiment was laid in randomized block design with two replications. Observations were recorded on fourteen characters *viz.,,* days to 50 per cent flowering, sympodia/plant, bolls / plant, boll weight (g), plant height (cm), day to maturity, seed cotton yield per plant (g), lint index, seed index (g), ginning outturn (%), 2.5 per cent span length (mm), fibre fineness/micronaire value (g/inch), fibre strength (g/tex), and uniformity ratio (per cent).Estimation of heterosis was done over mid parent, better parent and three standard checks *viz.,,* PKVDH 1, PKV Suvarna and NACH 12.

Analysis of variance carried out for fourteen characters, showed significant treatment differences for all characters studied. It indicated presence of substantial genetic variability among the selected parental lines.Among eleven parental lines, most of the lines were found to be best general combiner, which had significant general combining ability effects(GCA) for seed cotton yield and its contributing characters and fibre quality traits *viz.,* PA 828 for days to 50 per cent flowering, days to maturity and seed cotton yield / plant. Parental line PA 848 was found good general combiner for bolls/plant. Parental line PA 848 was found good general combiner for lint index. The parent PA 08 was good

general combiner for days to 50 per cent flowering. Parental line AKA 9703 was found good general combiner for bolls/plant, seed index, seed cotton yield/plant, fibre strength, uniformity ratio and ginning outturn, whereas Phuledhawantary and AKA 7 for boll weight and plant height respectively. Out of thirty crosses, the cross PAIG 77 x Phuledhanwantary was found to have good specific combining ability effects, which had significant SCA effects for days to 50 per cent flowering,. The cross PA 740 x Phuledhanwantary had good specific combining ability effects (SCA) for plant height. Whereas, cross PA 848 x Phuledhanwantary recorded high specific combining ability effects (SCA) for boll weight, lint index, bolls / plant and seed cotton yield / plant; PA 760 x PA 08 for seed index; PA 760 x AKA 7 forfibre fineness (micronaire); PA 740 x RAC 024fibre strength and boll weight and PA 760 x RAC 024 for ginning outturn.

1.25
Evaluation of diploid cotton (*Gossypium arboreum*) germplasm using augmented block design

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Augmented Block Design (ABD) aids plant breeders to evaluate large number of germplasm accessions in single location by employing desirable checks with genotypes. In the present study, 755 diplod cotton (*G.arboreum*) accessions along with 8 checks were evaluated in an augmented block design for yield and yield component traits in ICAR-Central Institute for Cotton Research, Regional Station, Coimbatore during *kharif* 2015-2016. The analysis of variance revealed significant mean sum of squares for all traits for different sources of variation. The block effect (unadjusted) and the treatment effects (adjusted as well as unadjusted) were significant for all the traits. Similarly the effects due to checks and accessions were significant. The mean values of single plant yield, boll weight, seed index and ginning percentage were 25.70(g/plant), 2.7(g/boll), 6.06 and 32.85 per cent, respectively. A set of 14 accessions were out yielded than checks (37.10g/plant), 95 accessions were observed with higher boll weight(3.5g/boll), 41 genotypes were shown higher Seed Index (7.1) and five genotypes were having higher ginning percentage(39%). Fourteen genotypes namely AC 3265, AKH 496, PBS 1127 – SP1, AC 3522 B, AC 3216, H 503, H 509, AC 3097, AKA 13 – SP1, N 11-54-31-32, H 173, PBN 565, 3930 A and AC 3244 were identified with single plant yield more than 37 g/plant. Five genotypes *viz.,,* AC 727, AC 515, H 502 – SP3, *Arboreum* (Surat) – SP1 and O-S-217 – SP1 recorded more than 37 per cent ginning percentage. Six accessions were identified with high single plant yield (>37g/ plant) and early maturity (< 104 days) AC 3265, AKH 496, AC 3216, AC 3097, N 11-54-31-32 and AC 3244.

1.26
Screening of various upland cotton genotypes against cotton leaf curl disease in Punjab state

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Cotton is the King of the fibre crops commonly known as the "White gold". It is the main economic and industrial crop of our country serving prime raw material for textile mills. Among the various factors responsible for its low production and productivity in Punjab state during the last 20 years, cotton leaf curl disease (CLCuD) has been found to be one of the major limiting factors. CLCuD belongs to genus Begomovirus, caused by a single stranded circular Gemini virus, transmitted by the insect vector whitefly (*Bemisia tabaci*). An experiment (AICRP trial) was carried out during *Kharif* 2017 and 2018 to identify disease resistant lines against CLCuD at PAU, RRS, Faridkot, Punjab, which include thirty four entries representing all three cotton zones of India and RST 9 as check entry. The results of experiment indicated that out of thirty four entries, three entries showed susceptible reaction, thirteen entries gave moderately susceptible reaction and eighteen entries showed moderately resistant reaction whereas none of the entry showed resistance reaction and RST 9 gave highly susceptible reaction. Among the tested genotype, seven entries were promoted for confirmation trial in *Kharif* 2018. Out of seven entries three entries *viz.* F 2596, F 2662 and F 2462 gave resistant reaction and three entries namely HS 300, PBH 116 and CSH 3129 gave moderately resistant reaction and only one entry HS 298 gave moderately susceptible reaction where as susceptible check RST 9 gave highly susceptible reaction against CLCuD.

1.27
DUS characterization in upland Cotton

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The characterization of cotton germplasm using DUS descriptors is helpful for varietal identification and protection. Before a variety is registered as a cultivar and/or granted Plant Breeder's Rights,

its distinctness, uniformity and stability (DUS) is tested using descriptors. The study of DUS characters was carried out with the objective of characterizing 34 genotypes of cotton. The experiment was conducted in the experimental area of the Cotton Section, Department of Genetics and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar in *kharif* 2017-18. On the basis of 37 morphological characters provided by PPV and FRA for DUS testing in cotton information on morphological character, genetic variability, heritability, genetic advance as per cent of mean, correlation was generated. Results revealed that maximum variation among the morphological characters studied leaf colour, leaf hairiness, leaf appearance, leaf petiole pigmentation, leaf shape, plant stem hairiness, plant stem pigmentation, plant height (cm), plant growth habit, bract type, days to first flower, flower petal colour, flower petal spot, flower stigma position, anther filament colouration, pollen colour, boll bearing habit, boll colour, boll shape (longitudinal section), boll surface, prominence of tip in boll, boll opening, boll weight (g), proved to be useful and stable diagnostic characters which could classify the genotypes based on morphological traits. High GCV means variability present in a population is of heritable nature and selection will be effective while large difference between PCV and GCV means trait is influenced by environment to a greater extent. Seed cotton yield was significantly positively associated with plant height (cm), monopods/plant, bolls/plant, boll weight (g)/boll, lint index (g), ginning out-turn, seed index (g), seeds/locule, at both the levels. At genotypic level expressed significant positive association with number of locules per boll and also exhibited significant negative correlation with days to 50% flowering at both levels.

1.28
Cotton fiber and yield traits improvement initiative using consensus-based QTL hotspots and its targeted NGS sequencing data

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Cotton (*Gossypium* L.) is one of the best fiber crops, cultivated worldwide witha vast economy. In fact, South-Asian countries especiallythe Indian sub-continent are well-recognized for cotton trades. However, cotton yield in India is still compromised due to sub-optimum annual rainfall, susceptibility to insectpests, and poor gene pool. In spite of the progress enunciated, cotton production in India is substantially low. Thus, cotton yield in India is a matter of priority and a major concern that needs to be further explored.In addition to cotton yield, fiber quality is equally prioritized for cotton trade

market. In the last two decades, plenty of NGSand genetic data have been generated worldwide for various cotton genetic resources to understandthe yield components and fiber quality at the molecular level.To date, however, no such robust full proven hypothesis/findings have been established for cotton yield and fiber qualitybesides a few QTLs study. Hardly a successful example of QTL-MAS has been reported in the public domain.

Hence, we,at CSIR-NBRI are focusing on consensus mapping based QTL hotspots for fiber quality and yield traits and their targeted NGS sequencing to characterize the key genes/haplotype blocks governing the fiber quality and yield traits. Due to the low rate of polymorphism, the consensus map, on the other hand, is the right choice of mapping in cotton using more than one mapping population. SNP typing of 3 tetraploids (UAS-Gb x Gh pop, IARI-Gh x Gh pop, TNAU- Gh x Gh pop) and 2 diploids (CICR-Gher x Garb pop and UAS-Gher x Garb pop) mapping populationswith in house developed 50K SNP chip has been completed.With a large number of developed markers, a consensus genetic map compiling a maximum number of genetic markers used for three tetraploid mapping populations and two diploid populations were developed. The fiber quality data of five populations at 3 locations for two years will be gathered and the meta-analysis for QTL hotspots for the consensus map will be performed. With ten public domain data, a meta-analysisrevealed ~50 hotspots, which will be further analyze for identification of combined QTL hotspots of Indian mapping populations with that of the public domain data.

Besides this, another meta-analysis for boll weight trait has been carried out and inferred two QTL hotspots at chromosome 22 and Chromosome 25. However, these QTLs are harbored in larger regions of the chromosome, where candidate genes or genetic variants underlying BW are difficult to decipher. Thus, the characterization of these loci in the Indian Cotton core panel for identification of the possible haplotype blocks/QTNs could open new avenues for a cotton breeding program inthe future.

Water scarcity also severely affectsthe physiological and biochemical processes of plants, leading towards fiber quality and lint yield deficit. Therefore, we are also interested to dissect the consensus-based drought tolerance quantitative trait loci (QTLs) using a recombinant inbred line (RIL) mapping population and important public domain data of drought tolerance.In the meta-analysis, chromosome 8 was revealed to be harbored many QTL clusters (island) with drought tolerance. These QTL clusters of chromosome 8 could be assets for molecular breeding programs in the initiative of future climate resilience cotton.

In conclusion, we propose a sequence-based breeding approach which includes the use of independent or combination of parental selection on the basis of QTL hotspots-based haplotype blocks/genes for cotton yield and fiber quality traits.

1.29
Factors affecting regeneration in cotton

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Cotton is a major fiber crop in India cultivated more than 122.35 lakh ha (AICRP Annual Report, 2018). It plays a major role in sustaining the livelihood of an estimated 5.8 million cotton farmers and 40- 50 million people engaged in related activities such as cotton processing and trade. Cotton has significant role in the textile industry and economy of India, so improved cultivars of the upland cotton is the main focus of the plant breeders. Molecular biology and genetic engineering technology brought new notions to modify the crops with specific single or multiple gene(s). Cotton is fortunate crop to modify with genetic engineering technology for insect and herbicide resistant genes. However, the full potential of the genetic modification was hindered with lack of *in vitro* somatic cell regeneration (Trolinder and Xhixian 1989).Direct shoot organogenesis was attempted by a number of labs including ICAR-CICR, however the true transgenic development is possible only through single cell regeneration.

Cotton regeneration was first observed in *G. hirsutum*cv Coker 310 (Davidonis, and Hamilton, 1983). Later a number of group have reported that Coker lines especially 312 and 310 response well for somatic embryos development and regeneration. Nevertheless,among Coker lines (312 and 310) we have observed a number of factors especially growth regulators, type of sugar, culture medium, temperature and subculture timing affecting the callus induction and regeneration. Seed to seed variation was also observed among the seed lot used for germination, callus induction and regeneration. Various concentrations of growth regulators such as 2, 4-D, IAA, Kinetin 2ip, Zeatin were used. Among them 2, 4-D 0.1mg/L and kinetin 0.5 mg/L induced friable callus within 20 days. The fresh calli were sub-cultured on MS medium with double the concentration of KNO_3 and without NH_4NO_3 and growth hormone where embryogenic callus was obtained in 30-35 days. Carbon source such as sucrose, maltose and D-glucose were tested, among them D-Glucose filter sterilized was found substantial response for callus and embryo induction. Temperature (25 ± 1°C) and light intensity (2000lux for 16/8 hrs. D/N) were found optimum for somatic embryogenic development. Friable and embryogenic callus was transferred to SE medium containing double the concentration of KNO_3. After 50-60 days of culture, somatic embryos were observed. Four stages of somatic embryos such as globular, heart shaped, torpedo and cotyledonary leaves were observed. The different stages were sub-cultured and plantlets regenerated were transferred to rooting induction with 0.1mg/l

IBA, which induced viable roots, once the roots originated robust plant growth was observed. The complete plants were subjected to hardening insoilrite and established in soil. Thisstandardized protocol are being used for genetic transformation of *G. hirsutum cv Coker 312* genotype with 2-gene constructs namely CICR-Cry2Ab1Ac and CICR-Cry2Ab1Ac::Chitinase.

1.30
Evaluation of American cotton germplasm under late sown in Punjab

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American Cotton (*Gossypium hirsutum* L.)is a predominant species of cotton cultivated mainly for its lint not only in India but more than 80 countries of the world. It resides a distinctive position in the global trade because it is a very important agricultural and industrial crop. In Punjab state, the ideal time for sowing cotton is upto May 15 but about 20-30 percent sown after this time by the farmers due to late harvesting of wheat and other uncontrolled factors.So, there is anurgent need to carried out the screening of American cotton germplasm under late sown condition so that a suitable variety for late sown may be developed. The present study was conducted with 77cotton germplasm lines obtained from CICR Nagpur with three check varieties in augmented design following 67.5 x 60 cm spacing during *kharif*, 2017-2018 at PAU, Regional Research Station, Bathinda and sowing was done in last weak of May. Each plot consisted of two rows of 4.80 m length and observations were recorded on five randomly selected plants from each genotype for seed cotton yield and its contributing characters.Under late sown condition, the genotypes IC 292139 (171.43g/plant) followed by IC 357210 (147.62g/plant) and IC 357420 (135.24g/plant) were recorded highest seed cotton yield as compared to check varieties.Lint yield (0.991) and boll number per plant (0.683) showed strong positive correlaton with seed cotton yield. So, lint yield and boll/plant as the important yield components and may be important in formulating selection criteria for genetic improvement of seed cotton yield in cotton.

1.31
A sociological comparison on *Bt cotton* growers in Haryana

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Despite being one the top most cotton growing countries in the world, the cotton yields on India are one of the lowest. Cotton the 'white gold' is premier industrial crop of major cotton growing countries like China, India, United States of America, Pakistan, Brazil, Uzbekistan, Egypt, Argentina, Australia and Turkey which account for nearly 85 per cent of the total global production. The study was conducted in various villages of Sirsa, Hisar, Fatehabad and Bhiwani districts of Haryana state from 2014-2015 to 2016-2017 on 360 farmers. Interview Schedule was prepared to collect the data of the experiment. Data were analyzed and tabulated to draw the inferences. The findings of the study revealed that the average yield of *Bt cotton* was more than American non *Bt*/ *desi* cotton for the last 6-7 years. But due to attack of whitefly and less production of *Bt* cotton, farmers are shifted from *Bt* cotton to non *Bt*/ *desi* cotton in 2014-15 in Hisar district of Haryana. Moreover production of *Bt* cotton in Sirsa district was more than Hisar district. It was found in Fatehabad district of Haryana in 2015-2016 that 20.00 per cent of the respondents had low level of adoption regarding *Bt. cotton* technology while 26.00 per cent and 74.00 per cent had it medium and high respectively. Many socio-economic variables affect the adoption level of *Bt cotton* growers in Bhiwani district in 2016-2017. It was also suggested that training should be imparted to create awareness among farmers about cultivation methods, seeds, manure and pesticides for *Bt cotton*.

1.32

Adaptation of traditional *phulkari* embroidery designs on cotton *Khadi* for *Kurti*

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Phulkari, a rural tradition of handmade embroidery, literally meaning " flower work ", and Bagh, a garden, have been the most popular ones since their early origin was perpetuated by the women of Punjab during the 19th century and till the beginning of the 20th century. The knowledge of this art was passed from one generation to the other. *Phulkari* embroidery evolved in many forms and there was one different design for every occasion. The motifs are made up of horizontal, vertical and diagonal stitches producing geometric patterns. *Phulkari* embroidered on home spun, locally woven and dyed coarse *khadi* because it is strong, long lasting and easy to embroidery on as it involved counting of threads. The work of '*Phulkari'* was woven by pure silk threads on a cloth of 'khaddar', a heavy cotton that is locally woven which was hand spun cotton. Embroidery could be easily done in short and long darning stitch. The present study was done on "Adaptation of Traditional *Phulkari* Embroidery Designs on Cotton *Khadi* for *Kurti"*. Total forty five motifs were selected from markets of Patiala and Hisar. Out of forty five fifteen motifs got highest preference from expert's. Out of fifteen motifs five top most motifs were selected for the design development. The designs were geometric and very much stylized. These designs were created through Corel Draw. These designs were placed on cotton *khadi kurti*. These kurtis were assessed from experts. *Phulkari* embroidery also available in market on *duppatta*, ladies *sarees, scarfs* on other fabric like sifon with stylized designs,

CROP PRODUCTION, MECHANIZATION AND ECONOMIC DEVELOPMENT

2.1

Effect of sewage sludge and inorganic fertilizers on productivity and fertility of soil under cotton wheat cropping system

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A field experiment was initiated in 2016-2017 at Soil Research Farm of CCS HAU, Hisar, to study the effect of sewage sludge and chemical fertilizers on yield, nutrient uptake and fertility status of soil under cotton-wheat cropping system. The experiment was laid out in a split-plot design. During these three years, the following treatments were applied to main-plots *viz.,* SS (Sewage sludge)@ 5 t /ha, SS+N+(50%P), SS+N+(75%P), SS+N+(100%P), RDNP. After the harvesting of wheat, cotton crop was sown and main-plots were divided into sub-plots and then following treatments were applied *viz.,* N+(75%)PK , NK+(75%P) , NP+(75%K), NPK. The treatments were replicated thrice. Application of SS+N+(100%P) x NPK level of interaction recorded highest wheat grain (5220 kg /ha) and straw yield (9906 kg /ha). The mean grain and straw yield of wheat under RDNP was statistically *at par* with SS+N+(75%P). The similar combination of SS and inorganic fertilizers recorded highest seed cotton yield (4070 kg /ha) and stover yield (5427 kg /ha). The highest NPK content in both crops were observed in SS+N+(100%P) x NPK level of interaction *viz.,* 222.57, 24.89 and 12.41 kg /ha in wheat grain 114, 15.66 and 49.71 kg /ha by cotton seed, respectively. The heavy metal content was below the permissible limits in both plant and soil. The organic carbon showed an increasing trend from its initial value *viz.,* 0.42 per cent. The soil available N and K decreases from its initial value while available P showed an increment. The combination of SS x N+(75%PK) recorded highest micronutrient and heavy metals content in soil. The MBC of soil varied non-significantly and highest was observed in RD NP x NPK level of interaction.

2.2
Identification of soil parameters influencing yield and fibre qualityin ELS cotton

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Cotton is one the most important commercial crop of India. The increase in productivity alone could not benefit the cotton growers, as quality of cotton fibre is primary concern for fetching higher price. The genetic character of cotton plant regulates these fibre traits but the growing soil and climatic conditions available throughout the life cycle determine the quality of fibre. Since very little information with respect to influence of soil parameters on fibre yield andquality is available especially inExtra Long Staple (ELS)cotton. Hence, the present investigationwas carried out tostudy the relationship between soilcharacters with yield and quality parameters ofELS cotton withobjective to identify the influencing factors.The study was conductedat *Kinathukadavu* block of *Pollachi*taluk of Coimbatore district on selectedthree soil series includes*Irugur,Palladam* and *Peelamedu*. The data on seed cotton yieldwas collected for selected genotype in farmers' fields comes under the above said soil series. The study concentrated on the domain within the block to avoid variation by rainfall and method of cultivation. Soil parameters includes, soil productivity index, land capability,permeability,water holding capacity and soil erosion, were collected from records of Department of Agriculture, Tamil Nadu. Soil depth, soil texture, calcareousness level, soil reaction andcation exchange capacitywere measured and analysed. The soil parameters were correlated with yield and quality parameters. The collected *kapas* samples were analysed by using high volume instruments.

The results revealed that positive significantcorrelation was found with soil productivity (r=0.48), land capability (r=0.59), soil texture (r=0.48), permeability (r=0.48), soil depth (r=0.68),soil productivity(r=0.19) and water holding capacity(r=0.19) with seed cotton yield of ELS cotton. The negative correlation of ELS cotton yield was found with soil reaction(r=-0.19).The results on relationship between soil characters and quality parameters of ELS cotton found that 2.5 per cent span length(mm) was significantly and positively influenced by soil productivity grades (r=0.839), and available potassium (r=0.699). Fibre strength(g/tex) was significantly influenced by land capability class (r=0.884) and available potassium (0.928).Micronaire was positively significantly influenced by soil productivity grades (r=0.793).

2.3
Suitability of different tillage systems over conventional tillage for cotton production

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Cotton has become more mechanized crop. Cost of cultivation has been increased due to intensive use of heavy machinery to perform different field operations especially tillage. Different tillage systems having different agronomic benefits. So, different tillage systems were investigated to determine their benefits over conventional tillage systems for cotton production. Experiment consisting five treatments *i.e.* strip tillage (strip tillage and sowing in single operation), zero tillage, mould bold *f.b.* conventional tillage, sub soiling *f.b.* conventional and conventional tillage (control). Germination, seedling establishment and plant stand were better under conventional, bould bold *f.b.* conventional and strip tillage as compared to zero tillage. Plant height and sympods/ plant were significantly higher under strip tillage and mould bold *f.b.* conventional tillage, while significantly least under zero and conventional tillage. Bolls/plant were also significantly higher under strip tillage and mould bold *f.b.* conventional tillage as compared to zero tillage, although sub soiling *f.b.* conventional tillage and zero tillage were statistically *at par* with conventional tillage with respect to bolls/plant. Strip tillage and mould bold *f.b.* conventional tillage produced significantly higher seed cotton yield by margin of 17.2 and 6.5 per cent as compared to conventional tillage. Seed cotton yield was increased by 7.3 per cent under sub-soiling tillage, while reduced by 8.1/under zero tillage as compared to conventional tillage. From productivity and resource conservation point of view strip tillage was far better over all the tillage systems for cotton production.

2.4

Productivity and economic sustainability of rainfed cotton and soil health under conservation tillage and integrated nutrient management in semi arid climatic conditions of Maharashtra

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A field experiment was conducted to study the productivity and economic sustainability of rainfed cotton and soil health under conservation tillage and integrated nutrient management on Vertisols during 2010-2011 to 2015-2016 at Dr. PDKV, Akola. The experiment comprised of eight treatments including 100 per cent recommended dose of fertilizers (60:30:30 NPK kg /ha) and the various combinations integrating 50 and 25 per cent N through FYM, wheat straw, glyricidia green leaf manuring (GLM) and compensation of RDF to cotton . The experiment was laid out in randomized block design with two sets of conditions namely, conservation and conventional tillage replicated thrice. The experimental soil was moderately alkaline in reaction, low in available N, medium in P and high in available K. The plot wise soil samples were collected and analyzed for various soil properties as per standard methods.

The pooled results revealed that the significant increase in cotton yield was recorded under conservation tillage with improvement in organic carbon, available nitrogen and higher monetary returns as compared to conventional tillage. The integrated use of 50 per cent N through GLM + compensation of RDF through chemical fertilizers recorded significantly higher seed cotton yield, sustainable yield index with improvement in soil quality indicators (physical, chemical and biological) and was *at par* with the application of 50 per cent N through FYM + compensation of RDF through chemical fertilizers. The highest net monetary returns and B:C ratio was obtained with 50 per cent N through GLM + compensation of RDF through chemical fertilizers.

Hence, it can be concluded that conservation tillage along with integrated use of 50 per cent N through glyricidia green leaf manuring as an alternative to FYM and compensation of RDF through chemical fertilizers found beneficial in yield and economic sustainability of cotton in semi-arid region of Maharashtra improvement in soil fertility under rainfed condition.

2.5

Enhancing nitrogen use efficiency in *Bt* cotton

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A field experiment was conducted during *kharif* 2018 at Main Agricultural Research Station, Raichur. The soil of the experimental site was medium black with pH 7.8, Initial soil available Nitrogen, phosphorus and potassium were in medium range. The experiment was conducted with RCBD having 7 treatments replicated thrice. The treatments were: T_1: N_0 Control (without N), T_2: 100 per cent of RDN (Band application in 2 splits at basal and flowering), T_3: 75 per cent of RDN(Band application in 2 splits at basal and flowering), T_4: 75 per cent of RDN + Placement(Spot application in 2 splits at basal and flowering), T_5: 75 per cent of RDN + Placement (Spot application in 4 Split: basal, Squaring, flowering, Boll development), T_6: T5+ Foliar application of 1 per cent urea (3 times: Squaring, flowering, Boll development and T_7: T6+raising of fodder cowpea between rows incorporated before flowering. The experimental results reveals that significantly higher seed cotton yield (3064 kg/ha) was recorded with T_7 followed by T_6 (2862 kg/ha) which found *on par* with T_7. The higher seed cotton yield with T_7 was attributed to higher sympodial branches/plant (31.6), bolls/m^2 (73.5) and boll weight (5.48). Higher gross returns (Rs.154566), net returns (Rs.96488) and B: C ratio (2.40) was also obtained with T_7. Higher nitrogen use efficiency was also recorded with T_7 (22.70 kg/ kg N applied).

2.6

Effect of different sources of nutrients on organic cotton production under rainfed upland ecosystem of Odisha

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A field experiment was conducted at the research farm of All India Coordinated Research Project on Cotton located in Regional Research and Technology Transfer Station, Bhawanipatna under Odisha

University of Agriculture and Technology during *kharif* 2016-2017, 2017-2018 and 2018-2019. The soil of the experimental site was clay loam, low in available N, medium in available P and K with pH of 6.1. The trial was laid out in randomized block design with three replications and eleven treatment *viz.,* $\mathbf{T_1}$: Absolute control (No organic and inorganic), $\mathbf{T_2}$: Control (RDF through inorganic), $\mathbf{T_3}$: RD of Nutrient through organic based on P equivalent basis (12.5 t /haFYM), $\mathbf{T_4}$: Seed treatment and soil application of biofertilizers (Azotobacter and PSB) and foliar application of PPFM @1 per cent at flowering and boll development stage, $\mathbf{T_5}$: *Neem* cake 250 kg /ha , $\mathbf{T_6}$: Raising of sunhemp between rows and incorporated before flowering (12 t /ha), $\mathbf{T_7}$: Intercropping with soybean and crop residue application after pod plucking (1.5 t /ha), $\mathbf{T_8}$:T_4 + Neem cake 250 kg /ha, $\mathbf{T_9}$: T_4 + Raising of sunhemp between rows incorporated before flowering (12 t /ha), $\mathbf{T_{10}}$: T_4 + Neem cake 250 kg /ha + green manuring with sunhemp and $\mathbf{T_{11}}$: T_4 + *Neem* cake 250 kg /ha + green manuring with soybean. The recommended dose (RD) of fertilizer for cotton in Odisha is 90:45:45 kg /ha. The cotton variety Suraj was sown during the first week of July each year with a spacing of 90 x 60 cm. The crop was raised organically with different sources of nutrients as per the treatments.

Results of the experiment (pooled data over three years) revealed that different growth and yield parameters and seed cotton yield were significantly affected by different treatments. The treatment RD of nutrient through inorganic source (T_2) recorded significantly the maximum seed cotton yield (1657 kg /ha) which was *at par* with that obtained from RD of nutrient through organic sources based on P equivalent basis (T_3) with 1615 kg /ha. Absolute control (No organic and inorganic) recorded the lowest seed cotton yield (965 kg /ha).

T_2 recorded significantly the highest plant height (103.67 cm), minimum monopodia (1.71), maximum sympodia (15.38), maximum bolls/m^2 (41.51) and boll weight (4.1 g). T_3 was statistically *at par* with T_2 with respect to all the parameters like plant height (99.73 cm), monopodia (1.75), sympodia (13.84), bolls/m^2 (35.03) and boll weight (4.0 g). The absolute control recorded the minimum growth and yield parameters among all the treatments.

The uptake of N, P and K was significantly affected by different treatments depending upon their initial availability in the soil, amount of nutrients applied and the growth of the plants. The uptake was significantly the highest in T_2 (78.8, 25.8 and 76.4 kg/ha N, P and K, respectively) followed by T_3 (75.6, 24.8 and 71.9 kg/ha N, P and K, respectively). The uptake was the minimum in absolute control T_1 (46.6, 10.8 and 39.5 kg/ha N, P and K, respectively).The availability of these nutrients slightly increased at harvest than that in the initial stages (before sowing) in all the treatments.

The treatment RD of nutrient through inorganic (T_2) recorded the maximum gross return/ha (Rs 90,292), net return (Rs 53,259) and B:C ratio (2.44) followed by the treatment RD of nutrient through organic sources based on P equivalent basis (T_3) with gross return/ha (Rs. 88,038), net return (Rs. 50,471) and B:C ratio (2.34). The lowest gross return (Rs. 52,574), net return (Rs. 18,408) and B:C ratio (1.54) was recorded in absolute control.

2.7
Management of leaf reddening in *Bt* cotton through foliar nutrition

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A field experiment was conducted at Main Agricultural Research Station, Raichur during *kharif* 2018-2019 with eight treatments replicated thrice in a completely randomized block design to assess the effect of conventional and multi nutrient fertilizers through foliar sprays on management of leaf reddening in *Bt* cotton. The results revealed that incidence of leaf reddening in *Bt* cotton was decreased significantly on application of RDF along with foliar spray of $MgSO_4$ (1%) + 19:19:19 (1%) at flowering, boll initiation and boll development stages. Similarly, the extent of management of leaf reddening incidence was *on par* with the application of RDF along with foliar spray of laboratory prepared multi nutrient bio mix solution @ 10 ml/litre at flowering, boll initiation and boll development stages. Therefore, the above treatments respectively recorded significantly higher seed cotton yields (3226 kg /ha and 3005 kg /ha) over the other treatments. The quality parameters of cotton were also of high grade in these treatments. The foliar nutrition of *Bt* cotton helped in better management of leaf reddening as well as in meeting the nutritional demand of the crop at different physiological growth stages and thus higher gross returns (Rs 1,74,222 /ha), net returns (Rs 1,12,579 /ha) and B:C (2.83) was achieved with treatment: RDF along with foliar spray of $MgSO_4$ (1%) + 19:19:19 (1%) at flowering, boll initiation and boll development stage and which was *on par* with the treatment: RDF along with foliar spray of bio mix @ 10 ml/litre at flowering, boll initiation and boll development stages. Finally, it can be concluded that leaf reddening in *Bt* cotton can be effectively managed and one can fetch higher returns through inclusion of foliar nutrition as a standard practice of crop nutrition in *Bt* cotton along with standard pest management and agronomic practices.

2.8
Adoption of drip fertigation is need of hour to improve productivity of cotton and doubling farmers income

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Cotton is very important cash crop grown in India. It is also known as WHITE GOLD. It is cultivated in 117.6 lakh ha area and its productivity is very low 527 kg lint / ha.Area under Cotton has increased due to *Bt* technology. Farmers has started adoption of *Bt* varieties from year 2002. Almost more than 90 per cent cotton cultivated is *Bt*. In central zone of cotton in Maharashtra cotton is cultivated on 38.27 Lakh ha and productivity is just 356 kg lint / ha. Though area under cotton in Maharashtra is highest however productivity is lowest in a country. Constraints of low productivity in Maharashtra are is mainly lack of irrigation facilities, irregular monsoon, no moisture available in a soil at boll development stages in Cotton grown areas. Most of the cotton crop cultivated as rainfed crop. In MS 95 per cent Cotton is cultivated under rainfed conditions and only 5 per cent area is cultivated under irrigation.

Maharashtra is a pioneer in adoption of drip irrigation technology in a country. Farmers has stared adoption of this technology from 1987-1988.. Around 24 lakh ha area is brought under this technology in Maharashtra. .Cotton farmers has started adoption of drip irrigation from year 2006. Around 4.28 lakh ha Cotton area is brought under drip irrigation in Maharashtra. Results of Drip fertigation in Cotton are amazing, Farmers has harvested Cotton yields from 1050 to 2161 kg lint / ha which is more than World's cotton yield. And earning double earning than traditional Cotton cultivation. Rain fall do not match with the growth stages of cotton crop. Due to withdrawal of monsoon during boll development stages results low yields of cotton, Drip irrigation maintains field capacity in soil, water and nutrients are efficiently managed through drip fertigation technology which leads to get bumper yield of cotton. This model is now replicated in Gujarath , Madhya Pradesh, Andhra Pradesh. Yields of cotton is increased by 200 – 300 per cent by adoption of this technology. Yields are increased due to hybrid *Bt* varieties, drip irrigation and fertigation technologies**.** Soil - water - plant relationships get maintained under drip irrigation, crop never get water stress at any stages, It also improves efficiency of fertilizers, minimises dropping of squares, flowers. Also observed better boll development. Hence adoption of drip fertigation is a need of hour to improve Cotton productivity to get doubling farmers income.

2.9

Fertigation for improving nutrient, water use efficiency and productivity of *Bt* cotton in rainfed vertisols

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Cotton is one of the most important commercial crop in Andhra Pradesh. The cotton crop is very sensitive to moisture stress. Excess moisture in the initial growth stages and uncontrolled water stress at later stages may adversely affect the cotton yield. Cotton is mostly grown under rainfed situation and if water is available farmers irrigate the fields in flood method which leads to severe flower and boll drop. The harvested rain water can later be used during critical stages of the crop growth when rainfall is limited with adoption of modern irrigation technologies like drip irrigation, which offers efficient and judicious use of irrigation water. Drip irrigation has been shown to increase crop water productivity of cotton. Being a wide spaced row crop, drip irrigation offers much scope in terms of enhancing cotton productivity for yield and water. But, the information on scheduling of irrigation based on evapotranspiration and nutrient management through fertigation in *Bt* cotton in vertisols is very much lacking. Keeping this in view a study on performance of *Bt* cotton under drip irrigation in Vertisols was conducted at Regional Agricultural Research Station, Lam, Guntur with the objectives to work out optimum nitrogen dose and suitable drip irrigation regimes in *Bt* cotton during 2013-2016 with four irrigation levels based on Epan (0.6, 0.8, 1.0 and control) through surface drip irrigation as main treatments and three nitrogen levels (90,120 and 150 kg N /ha) as sub treatments in split plot design with three replications. The fertilizers were applied through fertigation. The results of the study revealed that significant differences were observed in growth, yield contributing characters and seed cotton yield with different levels of irrigation and nitrogen. Interactions were non significant. The seed cotton yield was significantly superior when irrigation was scheduled at 0.6 Epan. Irrigation scheduled at 0.8 and 1 Epan recorded less yield than 0.6 Epan . Control (rainfed) treatment has recorded the lowest yield. Maximum seed cotton yield was recorded with application of 150 N kg/ha. Highest WUE was recorded at 0.6 Epan and NUE in 90 kg N /ha treatment. The physical and quality parameters were not influenced by the drip irrigation and nitrogen levels tested.

2.10
Influence of tillage and weed management practices on cotton-green gram cropping system

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Cotton crop is the main *kharif* crop in irrigated middle-western plain of Gujarat. Losses in seed cotton yield due to the presence of unwanted plants called weeds. The combination of pre and post emergence herbicides is required to be integrated for effective weed management to increase seed cotton yield. For better establishment of crop stand, well pulverized seed bed plays an important role. Tillage is considered as most effective and efficient technique for preparation of seed bed and to control the weeds. Conservation tillage practices are the alternatives which accumulate organic matter in the soil surface, enhance water absorption capacity, and improve soil physical, chemical, and biological properties. Keeping this in view, a field experiment was conducted during *kharif-rabi* season of 2016-2017 at AICRP-Weed Management, Anand Agricultural University, Anand (Gujarat) to study the effect of tillage and weed management practices in cotton-green gram cropping system. Results indicated that in cotton total weed density and dry biomass at harvest was recorded the highest under zero tillage + zero tillage and zero tillage + residue treatments, respectively. Significantly the highest seed cotton yield was obtained under conventional tillage treatment (2.52 t/ha) and pendimethalin 900 g/ha PE *fb* IC+HW at 30 and 60 DAS (2.33 t/ha). While in greengram, significantly the lowest weed density and weed dry biomass (7.19 no./m^2 and 6.90 no./m^2) was recorded at 30 DAS in conventional tillage followed by conventional tillage (CT-CT) treatment, respectively. The highest yield of greengram was recorded under zero tillage + residue followed by zero tillage + residue (ZT+R-ZT+R) treatment and pendimethalin 500 g/ha PE *fb* IC + HW at 30 DAS. The variable results were observed with respect to various tillage practices in suppression of density and dry weight of weeds in cotton-greengram cropping system. Different tillage practices showed significant differences with respect to seed yield of greengram. Significantly the highest seed and haulm yields were recorded under zero tillage + residue followed by zero tillage + residue treatment whereas, significant differences among other treatment were not found.

2.11
Yield, nutrients uptake and post harvest available nutrients in soil by integrated nutrient management practices

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Cotton (*Gossypium hirsutum)*, the **"White Gold"** is one of the most important commercial and industrial crop and plays a key role in economical and social affairs of the world. Being a heavy feeder and removes a large quantity of nutrients from the soil, thus, soil alone is not sufficient, hence needs to supply them through chemical fertilizers. Keeping this idea a field experiment was conducted experiment was during *kharif* season of 2018-2019, to study effect of different nutrient management practices on the productivity of cotton. The experiment was laid out in a randomized block design (RBD) with following treatments *i.e.* T_1- Control, T_2- RDF on soil test basis (N in three split doses at basal, 45 and 75 DAS), T_3- RDN + *Azotobacter*, T_4- (75 %RDN) + *Azotobacter*, T_5- (75 %RDN) + *Azotobacter* + 3 foliar spray of (2.5 %) urea, T_6- (75 %RDN) + 3 foliar spray of (2.5 %) urea, T_7- (100 % RDN) in four split doses @sowing, 45, 75, 100 DAS and T_8- (75 %RDN) in four split doses @sowing, 45, 75, 100 DAS + 3 foliar spray of (2.5 %) urea. The experiment results showed that the significantly seed cotton yield (2948.89 kg /ha), nutrient uptake NPK (67.66, 14.53 and 73.01 kg / ha) was highest in T_6.Also, the post-harvest available nutrient NPK (132.50, 21.6 and 265.92 kg /ha) was observed highest in different nutrients combinations.So, it was reported that the yield of cotton crop, nutrients uptake and post-harvest nutrient status of soil was affected with different nutrient management practices and increased with suitable combination of inorganic fertilizer and foliar application.

2.12
Enhancing water use efficiency of cotton crop through scientific scheduling of irrigation, drip system and structured water irrigation

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Agriculture is the cause and victim of water scarcity which accounts for about 70 per cent of global water withdrawals is constantly competing with domestic, industrial and environmental uses for a scarce water supply. As water becomes scarce, it is fundamentally important to tackle the issue by increasing the water use efficiency ensuring sustainable withdrawals to address water scarcity. Drip irrigation is accepted world over as the most efficient system to increase the water use efficiency. By adopting scientific scheduling with drip system, we can save water substantially. However, clogging of drip lines is the major problem while using salt water for irrigation. We have attempted to reduce the clogging of drip lines by adopting structured water irrigation. A Field experiment was conducted during summer 2018-2019 at Central Institute for Cotton Research, Regional station Coimbatore to study the efficacy of drip system under structured and bore well water irrigation, to fix the optimum irrigation scheduling for cotton while using structured water and to study the water use efficiency due to structured water irrigation. The experiment was conducted in split plot design with four replications. The main plot consisted of two irrigation water quality *viz.* Structured water irrigation and Bore well water irrigation. Five irrigation scheduling *viz.,* 1) 0.4 ETc Drip, 2) 0.6 ETc Drip ,3) 0.8 ETc Drip 4)1.0 ETc Drip 5) conventional irrigation were allotted to the sub plot. Structured water irrigation improved the hydration and the available soil moisture holding capacity than bore well water. Structured water irrigation resulted in enhanced water use efficiency (on an average 5 kg/ ha cm) than bore well water irrigation. Water saving due to drip ranged from 383 to 565 mm over conventional irrigation (40 to 60 % water saving). The boll weight and boll numbers were higher under structured water irrigation with the yield level varying from 29 to 33 q/ha as against 27 to 33 q/ha under bore well irrigation. The total water requirement for Mallika BG II cotton for Various growth stages at 1.0 ETc were worked out to be 158.3 mm for 0-25 DAS, 262.7 mm for 26-70 DAS,282 mm for 71-120 DAS and 28.4 mm for maturity stage (121-125 DAS). Scientific scheduling of irrigation through drip system and structured water irrigation is beneficial to cotton crop.

2.13

Nutrient requirement studies of *Gossypium hirsutum* cotton under irrigated conditions

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Field experiment was conducted to study the potential nutrient requirement of *Gossypium hirsutum* variety cotton under irrigated conditions of Agricultural Research Station, Arabhavi of zone-3 of Karnataka. Nutrient requirement studies were made with four levels of NPK *viz.,* F_1: (100 %) RDF (80:40:40 kg NPK/ha), F_2: (125% RDF), F_3: (150% RDF), F_4: (200% RDF) in RBD with four replications. Soils were of medium deep black with low N and medium in P and K content. Crop was sown during June month. Irrigation to the crop was made only when the crop was required. Insect and diseases were controlled with suitable control measures. Among the different treatments seed cotton yield was significantly increased with applications of (200% RDF) (F_4) (2392 kg/ha) as compared to any other treatments. However, it was *on par* with (150% RDF) (2252 kg/ha). Seed cotton was increased with every increase of nutrient levels from 100 to 125 per cent and further to 150 per cent RDF. Increased yield was associated with increased bolls/plant and seed cotton yield/plant. It can be supported by the previous workers that the higher levels of phosphorous applications found to improve the nitrogen use efficiency. High levels of P (75 to 100 kg P_2O_5 /ha) and K (122 to 150 kg K_2O/ha) were found to give higher targeted yields of cotton. When K is applied with N and P, the efficiency of K also increased. Effects are more pronounced under irrigated conditions than dry conditions. It was also supported by growth of the crop represented by plant height and sympodial plant. It shows that the nutrient levels of the present recommendations can be sufficiently increased to 150 per cent RDF. Studies can be repeated to confirm the results.

2.14
Influence of high density planting system on weed population in cotton (*Gossypium hirsutum* L.)

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A field experiment was conducted at Main Cotton Research Station, Navsari Agricultural University, Surat during *kharif* seasons of 2014 and 2015. The experiment was laid out in factorial randomized block design (control *vs.* rest) involving eight treatment combinations of two plant densities (D_1: 2,22,222 plants/ha and D_2:1,66,666 plants/ha) and four fertilizer levels (F_1:120:00:00:15 N:P_2O_5:K_2O:$ZnSO_4$ kg/ha, F_2:120:30:00:15 N:P_2O_5: K_2O: $ZnSO_4$ kg/ha, F_3:120:00:60:15 N:P_2O_5:K_2O:$ZnSO_4$ kg/ha and F_4:120:30:60:15 N:P_2O_5: K_2O: $ZnSO_4$ kg/ha) in addition to absolute control treatment (120 x 45 cm spacing with 160-0-0 kg NPK/ha).

The results with respect to weed count (weed plants/m^2) indicated that at 30 days after sowing (DAS) significant higher weed plants (60.1plants/m^2) was recorded in treatment D_2 as compared to 50.7 plants/m^2 in D_1 treatment. Whereas, at 60 DAS, wider spaced crop (D_2) recorded significant higher number of weed plants/m^2 (39.0) as compared to 33.6 plants/m^2 recorded in D_1. Different fertilizer levels as well as interaction effect of plant densities and fertilizer levels (D x F) could not influence significantly on number of weed plants/m^2 at 30 and 60 days after sowing. At both, 30 and 60 DAS, number of weed plants/m^2 recorded in HDPS was significantly lower than control. For Control *vs.* TM, significantly lower number of weed plants/m^2 were recorded in treatment D_1 only as compared to control at 30 and both D_1 and D_2 recorded significantly lower number of weed plants/m^2 than control 60 DAS.

The results pertaining to weed dry weight (g/m^2), closed spaced crop (D_1) recorded significantly lower weed dry weight (31.8 g/m^2) as compared to 37.1 g/m^2 in treatment D_2 at 30 DAS . Weed dry weight recorded in treatment D_2 (19.4 g/m^2) was significantly higher as against 16.7 g/m^2 recorded in treatment D_1 at 60 DAS. Different fertilizer levels did not show significant effect on weed dry weight (g/m^2) at 30 as well as 60 DAS. Interaction effect of plant densities and fertilizer levels (D x F) was found to be non-significant with respect to weed dry weight (g/m^2) for both recorded at 30 and 60 DAS. At 30 DAS, average weed dry weight recorded in HDPS (34.4 g/m^2) was significantly lower than control (40.8 g/ m^2). In case of Control *vs.* TM, treatment D_1 (31.8 g/m^2) and D_2 (37.1 g/m^2) recorded significantly lower weed dry weight as compared to control (40.8 g/ m^2). Average weed dry weight recorded at 60 DAS in HDPS (18.1g/m^2) was significantly lower than control (26.1 g/m^2) where as in Control *vs* TM, both the tested plant densities (D_1 and D_2) recorded significantly lower weed dry weight than control.

2.15

Fertilizer and canopy management of *Bt* cotton in high density planting system under rainfed condition

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Requirement of fertilizer and number of growth retardant sprays were studied for HDPS of *Bt* cotton at Cotton Research Station, Nanded (M.S.) during 2018-2019. Three fertilizer levels (100 per cent RDF, 125 per cent RDF and 150 per cent RDF) and two levels of Mepiquat chloride (one and two sprays) along with control were evaluated in split plot design with four replications under rainfed condition. *Bt* cotton hybrid (Bhakti BG II) was sown in high density planting system at 90 x 30 cm (37,037 plants /ha) after onset of monsoon in last week of June, 2018.

Significant reduction in plant height was observed due to sprays of Mepiquat chloride from 60 DAS onwards. Reduction in length of sympodia, mean internode length, stalk yield and increase in leaf thickness were found due to Mepiquat chloride sprays. Although number of branches was reduced due to foliar spray of Mepiquat chloride, bolls/m^{-2} and boll weight were increased over control. Two sprays of Mepiquat chloride (@ 50 g *a.i.* /ha at 50-65 DAS) has significantly increased yield /plant (84.03 g), seed cotton yield (2772 kg /ha) and harvest index (38.48%) over control (77.67 g, 2585 kg /ha and 35.73%, respectively). The Mepiquat chloride sprays were found to be economical with significant increase in NMR (' 82,422 /ha) over control. However, its single spray recorded highest B:C ratio (2.19).

Incremental fertilizer doses resulted to significant increase in leaf area at 60 DAS, sympodial length and stalk yield at harvest. Significant increase in bolls/m^{-2} (78.67) and seed cotton yield (2805 kg /ha) was recorded in 150 per cent RDF over 100 per cent RDF and was *on par* with 125 per cent RDF. Fibre maturity ratio was improved with additional fertilizer levels whereas increase in micronaire values was observed in Mepiquat chloride sprays. Ginning outturn and other fibre characters were not altered due to fertilizer levels and Mepiquat chloride sprays.

2.16
Appraisal of liquid microbial inoculants for cotton

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Cotton (*Gossypium hirsutum* L.) is the most important commercial crop of India, ranks first in area and second in global cotton production. During the year 2016-2017, it was cultivated over the area of 10.5 million hectares with the production around 35.1 million bales of 170 kg. In northern India, Punjab, Haryana and Rajasthan are the major cotton producers and Punjab covers an area of 5.05 m ha under cultivation with a productivity of 706.9 kg of lint/ha. Nonetheless,the crop nutrition requirement is very high. To meet such enormous nutrient requirements via chemical fertilizers would not only be exorbitant but could also grievously degrade soil health. Consequently, there is an urgent need to find alternative strategies that can ensure competitive crop yields, provide environmental safety and protection while maintaining long term ecological balance in agro-ecosystem. One promising method to reduce the use of chemical fertilizers is the application of plant growth-promoting rhizobacteria (PGPR) in agriculture. Plant growth promoting rhizobacteria (PGPR) plays a vital role in improving soil fertility as they competitively colonize plant roots system and enhance plant growth by plethora of mechanisms. The relationship between the PGPR and their host can be categorized into two basic levels of complexity; rhizospheric and endophytic. In neoteric era, myriad of formulation of PGPR are now available in the form of microbial inoculants either as liquid or solid carrier based. The major disadvantages associated with the solid carriers are shorter shelf life, poor quality, high contamination and unpredictable field performance. Liquid inoculant formulation is one solution to the problems associated with processing of solid carriers. Keeping aforesaid points in view, research work is being carried out at Punjab Agricultural University, Regional Research Station, Bathinda for the development of liquid microbial inoculants for cotton.

2.17

Site specific nutrient management (SSNM) for targeted yield in *Bt* cotton (*Gossypium hirsutum*)

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Abstract: Performance of three yield targets (M_{1-3}:3, 4 and 5 t /ha) and four nutrient practices (S_1- Vermicompost @ 2.5 t/ha in seed line, S_2- S_1+$MgSO_4$ 10 kg/ha in seed line, S_3- S_1+$MgSO_4$ 25 kg/ha in seed line, S_4- $MgSO_4$ 25 kg /ha in seed line + foliar nutrition of 1 per cent, and control-RDF with recommended practice $MgSO_4$ +19:19:19 + 1 per cent KNO_3 (thrice each)) was assessed using a spilt plot design during *kharif* 2014-2015 and 2015-2016 at College of Agriculture Farm, Raichur on medium black soil. SSNM for yield targets of 5 t /ha and supplementary nutrition of $MgSO_4$ both to soil and to foliage and foliar application of major nutrients (19:19:19 and KNO_3) recorded significantly higher plant height (158 cm), count of monopodials (3.0) sympodials (27.5), nodes on main stem (37.8) at final picking, good opened bolls (61.1 to 61.9), total developed bolls (66.2 - 66.9), lower leaf anthocyanin (0.048 at 135 DAS, respectively on pooled basis), lower LRI indices (1.10 at 135 DAS, respectively), higher productivity efficiency (0.52 during first year), seed cotton yield (5349 kg /ha) and net returns (Rs.2,45,120/-) over other yield targets and recommended practices.

2.18

Weed management in cotton

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Effective weed management is one of many critical components of successful cotton production. Cotton requires better weed control than either corn or soybeans. Because cotton does not compete well with weeds, especially early in the season, a given number of weeds will reduce cotton yield more than corn or soybean yield. Weeds also may interfere more with harvesting of cotton, and they can reduce lint quality because of trash or possibly stain. A field experiment was conducted during

kharif 2016 and 2017 on deep black soil of Agricultural Research Station, Dhadesugur coming under Northern dry zone of University of Agricultural Sciences, Raichur. The study was conducted to know the comparative bio-efficacy of Paraquat dichloride 24 per cent SL in controlling weeds in cotton, crop safety and yield in relation to Pendimethalin (30% EC), Quizalofop-p-ethyl (5% EC), Fluchloralin (45% EC) and hand weeding (weed free check).

The major weeds observed in the experimental fields were *Cynodon dactylon, Dinebra retroflex, Digitaria longifolia, Panicum javanicum (*Grasses), *Cyperus rotundus* was only the sedge and *Abutilon hirtum, Digeria arvensis, Corchorus trilocularis, Euphorbia hirta, Trianthema protulacastrum, Parthenium hysterophorus, Phyllanthus mederaspatensi and Leucas aspera* were the brod leaved weeds. Application of Paraquat dichloride 24 SL @ 2000 ml per ha (480 g a.i.) recorded significantly lower density of weeds at 28, 35 days after application and at harvest followed by application of Paraquat dichloride 24 SL @ 1250 ml/ha (300 g a.i.) as compared to other weed control treatments. Whereas, higher weed counts were observed in weedy check and there were no weeds observed in weed free check treatment. Significantly lower weed dry weight at 14, 28 and 35 days after application and at harvest (9.6, 3.4, 8.9 and 18.8 g/m^2, respectively) was recorded with Paraquat dichloride 24 SL @ 2000 ml per ha (480 g a.i.) and which was superior over the other weed control treatments. Whereas, higher weed dry weight (50.4, 68.7, 78.7 and 92.3 g/m^2, respectively) was observed in weedy check. Among different herbicidal treatments, application of Paraquat dichloride (24 SL) @ 2000 ml/ha (480 g a.i.) recorded significantly higher weed control efficiency at 14, 28 and 35 days after application and at harvest (81.2, 95.1, 88.7 and 79.6 per cent, respectively) and which was slightly superior over the treatment applied with Paraquat dichloride (24 SL) @ 1250 ml/ha (300 g a.i.) *i.e.* 70.9, 83.1, 80.1 and 74.0 per cent, respectively as compared to other weed control (herbicidal) treatments. Application of Paraquat dichloride (24 SL) @ 2000 ml/ha (480 g a.i.) recorded ssignificantly higher seed cotton yield (2826.7 kg/ha) which was *on par* with Paraquat dichloride (24 SL) @ 1250 ml/ha (300 g a.i.) *i.e.* 2713.3 kg/ha as compared to other herbicidal treatments. Whereas, significantly lower bolls/plant, boll weight and seed cotton yield were recorded in weedy check. This is due to severe weed competition particularly from grasses and broad leaf weeds.

2.19

Evaluation of high density planting system and fertilizer requirement of *hirsutum* cotton varieties

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A field experiment was conducted for three years during *kharif* (2014 to 2016) at Main Cotton Research Station, Surat. The experiment was laid out in factorial randomized block design with 18 treatment combination replicated three times. The treatments comprised of three planting density *viz.*,, D_1: 120 x 45 cm (18518 plants/ha), D_2: 60 x 15 cm (66667 plants/ha) and D_3: 45 x 15 cm (148148 plants/ ha), two varieties, V_1: GSHV-01/1338 and V_2: GBHV-164 and three nitrogen levels, N_1: 100 per cent RDN (180 kg/ha), N_2: 125 per cent RDN (225 kg/ha) and N_3 : 150 per cent RDN (270 kg/ha). The N fertilizer in the form of urea was applied in five equal splits at 30, 60, 75, 90 and 105 DAS.

The three years pooled results indicated that the planting density (D_1) recorded significantly higher plant height (118.9 cm) as compared to D_3 (114.5 cm). Among varieties higher plant recorded in V_2 was 119.3 cm as compared to V_1 (114.8 cm). In case of sympodia/plant, interaction of plant density (D) x variety (V), treatment combinations D_2V_1 and D_1V_2, both recording same sympodia/plant (23.3) was found significantly higher over D_3V_1 (21.6). Significant higher bolls was recorded in recommended planting density, D_1 (120 x 45 cm) as compared to closer spacing D_2 (60 x 15 cm) and D_3 (45 x 15 cm). Interaction, D_1V_2 *i.e.*, 120 x 45 cm spacing and variety V_2 (GBHV-164) recorded higher bolls/plant. Among N levels, significant higher bolls/plant was recorded in N_2 (16.6) as compared to N_1 (15.7), however it was found *at par* with N_3 (16.5). Treatment combinations D_1N_2 (36.4) and D_1N_3 (36.0) being *at par* with each other, both recorded significant higher bolls/plant over rest of the treatment combinations. Planting density, D_3 recorded significantly superior boll weight of 2.70 g as compared to D_3 (2.54 g) however, it was found *at par* with D_2 (2.67 g). Both these treatments, D_1V_2 (2.78 g) and D-$_2V_1$ (2.75 g) being *at par* with each other, recorded significant higher boll weight compared to rest of the treatments. The seed cotton yield recorded in D_2 and D_3 were 2125 and 2195 kg/ha, respectively which were significantly higher over D_1 (1921 kg/ha). Significant higher seed cotton yield recorded in V_2 was 2110 kg/ha as against 1921 kg/ha in V_1. N_3 recorded significant higher seed cotton yield (2083 kg/ha) over N_1 (1921 kg/ha) it was found *at par* with N_2 (2045 kg/ha). From the above three years experimental results it can be concluded that *hirsutum* cotton of compact culture type can be preferred under high density planting system. The spacing adopted should be 60 x 15 cm with application of 225 kg nitrogen/ ha in five equal splits at 30, 60, 75, 90 and 105 DAS. By following HDPS, higher yield and net income can be realized as compared to normal method of planting system (120 x 45 cm spacing with application of 180 kg N/ha and).

2.20
Effect of conservation agriculture and residue management on yield and economics of cotton maize cropping system

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Field experiments were conducted at Cotton Research Station, Srivilliputtur from 2017 - 2018 and 2018-2019 to study the effect of conservation agriculture and residue management practices on yield and economics of cotton (September to January) – maize (February to June) cropping system under irrigated conditions. The experiments were carried out in a randomized block design with three replications. The treatments consisted of control (T_1 - Conventional tillage + No residue management), Zero tillage (ZT) + No residue management (T_2) , ZT with 50 per cent residue management (T_3), ZT with 100 per cent residue management(T_4), Permanent Bed System (PBS) + ZT + No residue management (T_5), PBS + ZT + 50 per cent residue management (T_6), PBS + ZT + 100 per cent residue management (T_7).

The results revealed that though the conventional tillage without residue incorporation recorded the higher yields of cotton and maize in both the years of study, this was *on par* with that of zero tillage with 100 per cent and 50 per cent residue management and significantly superior than other treatments. The conventional tillage without residue incorporation also registered the highest cotton equivalent yield (3584 and 4046 kg/ha during first and second year of study, respectively) which were followed by ZT with 100 per cent residue management (3514 and 3924 kg/ha in I and II year) and ZT with 50 per cent per cent residue management (3481 and 3841 kg/ha in I and II year) and PBS + ZT + 100 per cent residue management (3413 and 3770 kg/ha in I and II year) in maize cotton cropping system.

The labour requirement was minimised by 20 labourers / crop/ ha under ZT than conventional tillage. Adoption of ZT and PBS in the cotton maize cropping system reduced the total cost cultivation by Rs. 12,000 / ha/ year and Rs.15,500 / ha/ year, respectively. Though the higher gross income was associated with conventional tillage without residue application, higher net income and BC ratio were registered by zero tillage with residue application. Thus, it is concluded from the study that zero tillage under cotton- maize tillage was technically feasible which was comparable with conventional tillage without residue application on yield besides higher economic benefits and lesser labour use.

2.21

Soil fertility status of cotton grown villages in Bhawanipatna block of western undulating agro-climatic zones of Odisha

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A field experimentation was carried out in thirty selective cotton grown villages of Bhawanipatna block of kalahandi under western Undulating agro-climatic zone of Odisha for determination of some physico-chemical characteristics of soil. Composite surface soil samples were collected from the villages and processed for different analysis. Results of present study reveal that the texture of that area varies from clay loam to sandy clay loam. The soil is non-saline in nature. The soil reaction varies from slightly acidic to alkaline. Organic carbon content of soil varies from low(3.97 g/kg) to high(12.90 g/kg). The available nitrogen status of soils of those sites are low ranging from 25.27 to 248.21 kg/ha. Available phosphorus and potassium status of soil vary from medium to high range. The data recorded in the present study will definitely help in evaluation of soil fertility status of the area as well as balanced fertilizer application for sustainable cotton production.

2.22

Poplar (*Populus deltoides*) as potential shelter belt in cotton wheat cropping system in semi arid regions

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The morphological features of the various Shelterbelt and windbreak can provide a definite answer about their efficacy for providing shelter on their downward sides and can reduce the harmful effects of wind and create a favorable micro-environment for agricultural crops. *P. deltoides* is the most widely planted species of poplar in India. It was introduced in India in the late 1950s. It is planted in plains of North- West India, *i.e.*, Western Uttar Pradesh, Punjab and Haryana and to some

extent in the outer plains/ valleys of Uttaranchal and Himachal Pradesh. Poplar tree can be the best option to be used as shelterbelt in cotton-wheat cropping system owing to its fast growth habit and deciduous nature. In cotton crop it can reduce the wind speed and hence can reduce evaporation losses thereby increasing water use efficiency and productivity of cotton. While due to its leaf shedding habit, it can also be used in succeeding wheat crop without much penalty in yield of wheat. Intercropping of cotton-wheat cropping system with Poplar can also be an important alternative as it will spur the growth rate of poplar due to frequent irrigation and hoeing on one side and will also provide agricultural income on the other side particularly in semi-arid regions. Further the effect of height, density as well as orientation of Poplar tree as boundary plantation and also as block plantations needs to be researched for its effect on wind regime, air temperature and soil properties and productivity of crops on the downward side. Besides that use of Poplar as bio protectant in saline and calcareous soils of semi-arid region can be an antidote to the decreasing productivity and land availability of major cereals. Due to its deciduous nature, there is probability of improvement in physical and chemical properties of soil due to rapid decaying of its leaf which can add significant amount of organic carbon to the soil, thereby increasing its water and nutrient holding capacity. For better adoption of Poplar as shelterbelt in cotton-wheat cropping system in semi-arid regions, there is need to further address the issues of effective width and spacing of Poplar tree as block plantation, initial survivability in water scarce environment, marketability and fluctuating prices. With proper management and supportive policies, there is huge potential of increasing per unit productivity, increasing farm income and better micro environment in the face of climate change by utilizing Poplar as shelter belt in cotton-wheat cropping system in semi-arid regions of India.

2.23
Effect of date of sowing on cotton yield and yield attribute

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The present study was carried out to evaluate the effect of dates of sowing *i.e.* early sowing, normal sowing and delayed sowing by 15 days interval on six cotton genotypes namely; G.Cot-10, G.N.Cot-22, Deviraj, G. Cot-15, G. Cot-19, G. Cot. Hy. 10BGII at Main Cotton Research Station, NAU, Surat during 2018-2019. The experiment was conducted in split plot design with three replications. The spacing was kept at 120 x 45 cm except the genotypes G. Cot-15, G. Cot-19 (60 x 10 cm). The study revealed that plant height at 50DAS and 100 DAS, seed cotton yield (kg/ha) was significantly deviated due to dates of sowing whereas plant height at 50DAS and 100 DAS, bolls/square meter, boll weight

and seed cotton yield (kg/ha) was significantly deviated due to genotypes. The significantly higher plant height was recorded in early sown condition. The genotype G.cot 19 was showed significantly higher plant height which was *at par* with G.Cot 15. The genotype G.cot 15 was showed significantly higher bolls/square meter which was *at par* with G.Cot 19. The genotype G.cot 15 was showed significantly lowest boll weight which was *at par* with G.Cot 19 whereas G. Cot. Hy. 6 BGII showed highest boll weight. The numerical higher bolls/square meter and boll weight was recorded in early sown condition. The significantly higher seed cotton yield was recorded in early sown condition. The genotype G. Cot. Hy. 6 BGII was showed significantly higher seed cotton yield which was *at par* with G.Cot 15 and G Cot 19 whereas Deviraj showed lowest seed cotton yield.

2.24
Preliminary agronomic evaluation of *Bt* cotton advance lines

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Cotton is the only genetically-modified crop being commercially cultivated by farmers in India. Although *Bt* cotton has reflected substantial economic and environmental benefits to the growers with decline in need of insecticides but this technology is commercialized only in hybrids in our country. Hybrid technology prevents the farmers to reuse their crop's seed, so cotton growers require annual purchase of costly seed. Moreover, hybrids are generally vigorous, long duration as compare to varieties resulting in low plant density and high fertilizers requirement for cultivation of *Bt* cotton hybrid. Several public institutes have been taken up the objective of incorporation of *Bt* gene into high yielding cotton varieties. With the development of *Bt* varieties (BG-I), farmers can reuse their crop harvest as a sowing material for next season crop. Moreover, varieties can be planted at higher densities and comparable yields can be obtained as compared to hybrids. In order to achieve this target, nine *Bt* cotton genotypes (PBHT 1, PBHT 2, PBHT 4, PBHT 5, PBHT 11, PBHT 12, PBHT 13, PBHT 16 and PBHT 17) along with two checks *viz.,* (PAU Bt1 and F 2228) were evaluated in *kharif* 2018 at PAU Regional Research Station, Bathinda for various agronomic traits. The observations on seed cotton yield (plot basis) and its contributing characters were recorded on randomly selected three plants. Among the genotypes PBH Bt 11 (2883 kg /ha) followed by PBH Bt 5 (2819 kg/ha) were recorded highest seed cotton yield as compare to check varieties. Therefore, these two genotypes can be used in further crop improvement programme.

2.25
Moisture stress management through use of different Osmo Protectants in cotton

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The role of different osmo protectants in plant tolerance to drought stress is significant because they regulate multitude of metabolic processes. The present study was therefore conducted to investigate the influence of foliar application of different PGR's and Nutrients, on morpho-physiological parameters for enhancing the productivity in Cotton under stress and unstress condition. The experiment consisted of eight treatments applied under both the conditions which are (2%) urea, (2%) KNO3, (1%) Thiourea, Salicylic acid @ 50ppm, Glycine Betaine @ 100ppm, Salicylic acid @100ppm and PPFM (1%). Among all the treatments foliar application of KNO3 at weekly interval of four sprays after 50 per cent flowering recorded significantly highest plant height, monopodial, sympodial, bolls/ plant, total dry matter production and boll weight /plant under stress condition as compared to unstress. Also (2%) KNO3 application recorded highest seed cotton yield (1970.3kg/ha) under stress condition as compared to other treatments and unstress (1558.1 kg/ha) and it was *on par* with Glycine Betaine @ 100 ppm single spray at 50 per cent flowering (1838.7 kg/ha) under stress condition.

2.26
Effect of soil depth on hybrid cotton fiber quality under rainfed conditions

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In Central India, cotton is cultivated on soils of varying depths ranging from shallow (<25cm) to deep black soils (>100cm) under rainfed conditions. Soil physico-chemical parameters like soil depth (shallow, medium deep, deep black), bulk density (1.4 to 1.7 Mg m^{-3}, soil texture (loam to clay), structure (five major classes), moisture (varied), temperature (25-40ÚC), strength (compacted,

uncompact) and fertility parameters (soil reaction, electrical conductivity, organic carbon, calcium carbonate and nutrient content) varied from low to high. The seed cotton production potential as well as fiber quality is modulated with soil and atmospheric growing conditions. On-station field experiments were conducted with three different commercial hybrids (Ajeet-155, Ajeet-199 and Ankur 3028) on three soil depths in order to understand effects of soil type, seed cotton yield and fiber quality during 2016 to 2018 under rainfed conditions at Central Institute for Cotton Research, Nagpur. Cotton was sown with the onset of rain in the second fortnight of June. The recommended plant spacing of90 cm between rows and 60 cm between plants was adopted. Soil and plant samples were analyzed by standard procedures. The data polled over years, analysis of boll size among the hybrids (Ajeet-155, Ankur 3028) were highly significant and *on par* compared to Ajeet-199. Between soils of depth varying bigger bolls were observed on deep black soil than others. However their interactions on boll size were non-significant. With respect to seed cotton yield differences were for hybrids, soil depth and the interactions (hybrid (H) x soil depth(S)). Among hybrids, productivity was greater on the deep black soils than on the shallow soils. Among hybrids, Ajeet-199 had significantly higher yield than the other hybrids. In general, plant height (cm) and dry matter (kg/ha) was higher for cotton grown on deep black soil than on the other soil depths. These results indicated that soil depth and moisture holding capacity influenced boll and fiber development. Similarly, among the hybrids (H) highly significant differences were observed on fiber quality parameters (Upper-Half Mean Length, Uniformity Index, Micronaire and Elongation Index). However, differences were non-significant on soil depth (S) and their interactions (H x S). These improved production and fiber quality parameters demonstrated that growing cotton on deep black soil is desirable under rainfed conditions.

2.27

High density planting is viable alternative for rainfed cotton production

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Cotton (*G.hirsutum* L.)is the most important fibre as well as commercial crop of India and Andhra Pradesh. It presumes importance in agriculture as well as in Industrial economy.

A field experiment was conducted on clay soils of Regional Agricultural Research Station Lam, Guntur during the year 2018 – 2019 under rainfed condition in compact cotton variety LHDP 1 . The

treatments consisted of three crop geometries S_1 - 60 × 10cm, S_2- 75 × 10cm, S_3- 90 × 45cm in combination with four nitrogen levels N_1- 45kg N /ha, N_2- 90kg N /ha, N_3- 135kg N /ha, N_4- 180kg /ha. The experiment was laid out in a randomized block design with factorial concept and replicated thrice.

bolls/square meter and seed cotton yield/ha were recorded maximum with closer crop geometry of 60 × 10cm. The number of bolls/square meter and boll weight were more with application of 180kg N /ha. The maximum seed cotton yield was recorded with application of 135kg N /ha and was *on a par* with 180kg N /ha.

The maximum gross returns, net returns and return/rupee investment were obtained at closer crop geometry of 60cm × 10cm than all the other crop geometry tested. The highest net return and return/rupee investment recorded with nitrogen level of 135kg N /ha, and was *on par* with 180 kg N /ha.

Results showed that the spacing of 60 × 10cm was found to be optimum to realize higher growth, seed cotton yield and net returns under high density planting system in the variety LHDP1. Increase in nitrogen application from 45kg N /ha to 180kg N /ha recorded higher growth and seed cotton yield and net returns. Application of 135kg N /ha was optimum for production of maximum seed cotton yield and net returns. However 90kg N /ha recorded return/rupee investment was *on par* with 135kg N /ha

2.28
Integrated weed management in *Bt* cotton

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Cotton is highly vulnerable to weed competition especially in the initial stage of growth. As the cotton is slow growing crop while the growth of many weeds is very fast therefore, they produce competition and also suppress the growth of cotton. Cotton being a long duration crop, the critical period of weed competition prevails up to 60 to 90 DAS and during this period the crop needs weed free condition for better results. Losses caused by weeds in cotton ranges from 50 to 85 per cent depending upon the nature and intensity of weeds. Weeds exhibit allelopathy, competition and parasitism. It is common practice with the farmers to take up manual weeding and frequent inter cultivation (hoeing) in cotton. But scarcity of labour and high soil moisture conditions due to frequent irrigation or heavy rains during *kharif* make the farmers unable to take up timely cultural practices

including hand weeding, besides such operations are time consuming, expensive and tedious. Hence, it has become imperative to control weeds by using herbicides in critical period and to get higher yields. Successful cotton production depends on an integrated management strategy that recognizes and adapts to the unique characteristics of the crop. Integrated weed management approach based on critical period of crop weed competition, involving different direct and indirect control measures, has been developed and widely adopted by farmers to overcome weed problem in cotton in a sustainable way. To prolong the useful life of herbicides it will be necessary to adopt integrated weed management practices. Integrated weed management incorporates any economic combination of weed control strategies which may include preventative measures, monitoring, crop rotations, tillage, crop competition, harvest weed seed control, the use of different herbicide sites of action in rotation, sequence, and mixtures, herbicide resistant crops, biological controls, crop competition, nutrition, burning, and hand weeding. The key is to vary weed control strategies to destabilize evolution, because history has shown us that any consistent practice to control weeds year after year will result in directed evolution towards their survival. Pre-emergence application of Pendimethalin in combination with Inter-culturing + hand weeding may be used for efficient weed control and higher yields in flat-sown cotton.

2.29

Effect of planting density and nitrogen management in cotton under rainfed condition

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A field experiment was conducted at College Farm, College of Agriculture, Navsari Agricultural University, Bharuch during *kharif* season in three consecutive years (2014-2015, 2015-2016 and 2016-2017) to study "Effect of planting density and nitrogen management in cotton under rainfed condition". The experiment was laid out in factorial randomized block design (FRBD) design. Total six treatment combinations having two levels of planting density viz., 120 x 45 cm (18518 pl/ha) and 120 x 60 cm (13888 pl/ha) ; and three nitrogen levels viz., 75 per cent RDN (90 kg N /ha), 100 per cent RDN (120 kg N /ha) and 125 per cent RDN (150 kg N /ha), each replicated four times were included in the trial. Significantly higher plant height (139.2 cm), branches/plant (2.8), sympodial branches/plant (15.8), bolls/plant (69.78), seed cotton yield/plant (274 g) and seed cotton yield (2008

kg/ha) were recorded with planting density 120 x 45 cm (18518 pl/ha) resulted in higher net returns (Rs. 75468/ha) and BC ratio (2.07). Among nitrogen levels, application of 125 % RDN (150 kg N/ha) gave significantly higher plant height (143.8 cm), monopodial branches/plant (3.0), sympodial branches/plant (16.4), bolls/plant (63.81), seed cotton yield/plant (231 g) and seed cotton yield (1919 kg/ha) as compared to rest of the treatments resulted in higher net returns (Rs. 70189/ha) and BC ratio (1.99). The results revealed that farmers growing rainfed cotton are advised to follow spacing of 120 x 45 cm (18518 pl/ha) with application of 150 kg N/ha for getting higher seed cotton yield and net realization.

2.30
Evaluation of interactive effects of altered sowing dates and nitrogen doses on population builds up of cotton whitefly (*Bemisia tabaci*, Gennadius)

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A field experiment was conducted during *kharif* season of 2016 at Entomology Research Area of CCS Haryana Agricultural University, Hisar with an objective of studying the effect of altered date of sowing and its interaction with the effects of various nitrogen doses on population build up of cotton whitefly. The experiment was conducted with split plot design (SPD). The result reveals that, the whitefly adults and nymphs population was maximum at late sown crop on 20th June (4.96 adults/leaf and 5.96 nymphs/leaf) while, the minimum population was found at timely sown crop on 7th May (2.48 adults/leaf and 4.62 nymphs/leaf). The late sown crop treated with higher nitrogen doses (100 kg/ha) was heavily attacked with CLCV disease (Cotton Leaf Curl Virus). The interaction between altered sowing dates and nitrogen doses had significantly different effects from each other. Thus it is clear that earlier sowing date in combination with lesser/recommended nitrogen doses led to least population built up of whitefly (1.08 adults/leaf) in cotton.

2.31

Analytical study of growth and instability in cotton production of India

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Cotton is one of the important fibre crop and the most widely grown commercial crops in India. Cotton is grown mainly in three zones of India *i.e.* Northern zone (Punjab, Haryana and Rajasthan), Central zone (Gujurat, Maharastra and Madhya Pradesh) and Southern zone (Andhra Pradesh, Telengana, Karnataka and Tamilnadu). More than 98 per cent of total area under cotton in India is in these three zones. The study is based on Compound Growth Rate and Instability of area, production and yield of cotton in the three zones of India (*i.e.* Northern zone, Central zone, Southern zone) for the period from 2004-05 to 2017-18. The result of the study shows that area and production of cotton shows significant Compound Growth Rate in Central zone, Southern zone and at all India level. Yield of cotton shows significant Compound Growth Rate only in Southern zone, whereas, in Northern zone, Central zone and at all India Level it is found non - significant. Area and Production of cotton registers highest Compound Growth Rate in Southern zone which are 6.35 per cent and 7.71 per cent respectively, whereas, for all India level the values are 2.89 per cent and 3.27 per cent respectively. The Coefficient of variation (used as measure of instability) in area and production of cotton is also highest for Southern zone which are 29.24 per cent and 32.26 per cent respectively. But the instability in yield of cotton is lowest in Southern zone which is only 9.34 per cent. This shows that Southern zone of India shows much better performance *w.r.t.* yield of cotton. The high instability in production of cotton in Southern India may be attributed to high instability in area under cotton.

2.32

Social impact assessment: Tools and technique

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In view of the fact that development is an ever growing process, its impact is also ever-increasing,

leading to rapid deterioration in environmental conditions and human health. Impact Assessment thus ensures that the potential problems are unforeseen and addressed at an early stage in the planning and design of the project. Social impact assessments help in identifying the likely positive and negative impacts of proposed policy actions, likely trade offs, and synergies, and thus facilitate informed decision making. Developed indicators especially for technical, institutional, socio cultural, commercial, economic and environmental aspects, have to be spelt out clearly and objectively so that it is amenable for precise quantification. Both quantitative and qualitative methods are used in social impact assessment studies. Various methods along with suitable example imply the core part of that methodology. Although there are many more methods for impact assessment, which one is more suitable than others; that totally depends on impact level, availability of time, data and human resources which will come up with an effective assessment report.

2.33

A study on the perceived contraints faced by the vegetables growers and invite suggestions to overcome these problems in Kendujar district of Odisha

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India is mainly a vegetarian country and second largest producer of vegetables (121.02 Million ton.), next to China (583.32 Million ton.) in 2013 (*FAOSTAT Website*). As per National Horticulture Database published by the NHB, during 2014-2015 India produced 169.478 million metric tonnes of vegetables from 9.542 million hectares. Odisha produces about 10.30 m.MT of horticultural produce from an area of 1.21 m.ha and accounts for 4.28% of the total horticultural production in the country. Odisha is the second largest producer of brinjal (20%) and cabbage (14%) of the total production in the country. The study was conducted in Anandapur, Barbil and Joda blocks of Kendujhar district, Odisha. Both purposive and random sampling procedure was followed for selection of the district, blocks, *Gram Panchayats*, villages and the respondents. The total sample size of the study was 80. The response was obtained from each individual respondent in a structured interview schedule which was pretested with 10 per cent samples other than the respondents of the study. The respondent indicated that majority (85%) of vegetable growers faced lack of storage facilities (cold storage) followed by inadequate physical facilities in the market (80%) as the problems and mostly (95%) vegetable

farmers suggested to provide regular information on market prices must be present in the marketing system of vegetables followed by increase in number of farmer's market (90%) as the suggestions. Increase in the storage facilities and processing industries will automatically improve contract farming which will reduce their risk and avoid distress sale of vegetables. To augment vegetable production and vegetable marketing in the state, the new proven and viable technology on vegetable production which should be diffused through various extension activities to accelerate its adoption.

2.34
Crop diversification in cotton growing districts of Maharashtra

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Crop diversification is practiced in rainfed areas to reduce the risk factor of crop failures due to drought. Maharashtra is one of the important cotton growing states in India where cotton is grown under rainfed condition. Many changes occurred in cotton production scenario during the past decade which affected the cropping pattern in the cotton growing districts of Maharashtra. A study was conducted to analyze the changes in crop diversification pattern in cotton growing districts of Maharashtra during 2000-2001 to 2015-2016. The data on crop areas were collected from the website of Ministry of Agriculture and Farmers Welfare, Govt of India for 18 important cotton districts in Maharashtra. for the period 2000-2001 to 2015-2016. Simpson Index of crop diversification was used for the present study which measures the dispersion of crops in a geographical area. Cotton area increased in 13 districts during the study period while there was a decrease in cotton area in another 5 districts. Simpson index of crop diversification (SID) ranged between 0.46 to 0.83 in cotton growing districts during TE 2015-2016, indicating that crop production in these districts is diversified. SID showed a negative growth during the period of analysis in almost all districts indicating that the degree of diversification is reducing and the crop pattern is moving towards specialization. In the long run if this trend continues, it may lead to higher risk in the crop production and other bottlenecks associated with specialized farming will be surfaced. dismutase and dehydrogenase as ageing increased in seeds. The study suggests that cotton seed deteriorates during storage and it is closely related to a decrease in activities of various scavenging enzymes but maximum decrease found in antioxidant enzyme activity was found in seed sample collected at third picking

2.35
Opinion of Cotton Grower about effectiveness of ATIC Toll free number of CCS Haryana Agriculutral University, Hisar - 125 004

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ATIC is unique facility and shall endeavor, the sale of seeds, plants, processed product , bio- fertilizers. ATIC (Agriculture Technology Information Centre) helps farmers in problems solving and decision making. The establishment of Agricultural Technology Information Centre (ATIC) is meant to provide such a mechanism beyond individual units of research information. The study was conducted in Haryana state with objective; to identify the cotton growers who use toll free number and to count the major problems faced by cotton growers. Approximately 400 farmers call on the toll free number of ATIC per month. Majority of the callers are from Haryana state. The cotton growers were selected from the list available in ATIC by using random sampling from district Hisar and Sirsa, two leading cotton growing districts of Haryana. It was concluded that the more call from Hisar District compare to Sirsa District. However in case queries regarding insect pest also more caller of Hisar compare to Sirsa District. The respondent of Hisar District opinion about ATIC Toll free number were useful (45.00%) and very useful (32.50) with got the 1st and 2nd rank respectively. Similar opinion of the Sirsa Distrct respondent about Toll free numbers were useful (40.00%) and very useful (25.00%) with got the 1st and 2nd rank respectively.

2.36
Studies on the effect of labour saving techniques in cotton cultivation

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Mechanization is the process through which agricultural activities can be improved in cost effective manner to achieve optimum crop production. In Tamil Nadu, cotton is grown in irrigated, rainfed and rice fallow crop. The irrigated cotton crop is sown in August and rainfed crop in September -

October with the onset of monsoon. Total land under cotton cultivation in Tamil Nadu is about 1, 48,000 lakh ha and productivity is 680 kg/ha. The reasons for low productivity have been reported as lack of irrigation facilities, poor control of insect pest and diseases and lack of mechanization. A field experiment was conducted during 2017-2018 to study effect of labour saving techniques in cotton cultivation The result revealed that, significantly the treatment combination including application of herbicides (PE and POE) along with intercultural operation using tractor drawn implements and drip fertigation recorded a yield of 2680 kg /ha which was comparable with mechanized land shaping (2569 kg/ha) and manual operation (2491 kg/ha). Utilizing the labour saving techniques (T6), 58 man days can be saved as compared to carrying out all the operations manually (T1). Lowest seed cotton yield was recorded under T6 including use of boom sprayer and T5 in which intercultural operations were done with animal and tractor drawn implements.

2.37
Impact analysis of shift in global cotton trade on Indian cotton scenario

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The decadal trends in area under cotton from 2007-2018 showed an increase of 17 to 25 per cent of total cotton area in the south zone, slight reduction in the north and central zones during the same period. Odisha registered an increasing trend from 0.81 to 1.19 per cent over the years. The Central zone showed a promising trend in yield increase, a negative trend in north zone during the second period. In case of South zone, it was a negative trend during both the periods. The cotton farmers were able to make profits over cost C2 in almost all the four periods with the ratio ranging from 1.25 and more than 1.25 during the first period (2007-2012). Decomposition analysis results indicate that the contribution of change in mean export quantity of Indian cotton was the dominant source for the change in average export value to the tune of 75.80 per cent during the period 2007 to 2018. Gravity model was estimated for five country pairs of major importing countries from 2012 to 2018. Most of the factors were significant. Distance variable was not a matter of concern for Indian cotton export.

From transitional probability matrices for the annual export data of raw cotton (in terms of volume) for the period 2007-2008 to 2016-2017, it is evident that China has been the only stable importer of Indian cotton. The transition probabilities for the importing countries, *viz.,* Thailand and Taiwan were found as zero in the study period, indicating instability in India's exports to these countries.

The present study suggests that the sharp decline in the export of raw cotton from India reflects our inability to retain the share in the traditional markets and explore new markets. We need to improve our export competitiveness by decreasing costs and improving yield and quality. High dependence on few markets would be risky in the long run. So new markets are to be tapped to export our Indian cotton.

2.38

comparative economics of major cash crops in western odisha: the evidence from village level study

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The performance agricultural sector influences the growth of Indian economy. Agriculture has been a way of life and continues to be the single most important livelihood of the masses. As far cash crops are concerned, cotton and sugarcane production are estimated to be a record 36.59 million tonnes bales and 350.02 million tonnes respectively in 2013-2014 crop year. Sugarcane is the main sugar producing crop that contributes nearly 78.2 per cent to the total sugar pool at global level. It occupies 3.5 per cent of the total cropped area in our country. Cotton as king of fibres, usually referred as white gold and one of the important commercial crops, plays vita role in economic, political and social affairs of the world. Cotton is the major cash crop of India accounts for 65 per cent of the fibre used in the textile industries. This paper focuses on the growth economics of cotton cultivation in western Odisha. From this study, per hectare gross income received was Rs.98047.40 and Rs. 45187.50 for Sugarcane and cotton respectively. The per hectare profit at cost C was the highest (Rs, 40178.70) in case Sugarcane followed by cotton (Rs. 21441.34). The benefit cost ratio at cost C was highest in case of cotton (1.90) followed by Sugarcane (1.69). The benefit cost ratio in both cash crops was observed more than one unity which indicates the cultivation of cash crops is economical viable under study area. Due to lack of technological interventions inputs were under utilized by the farmers in the study area. Thus it is use uneconomic to use imbalance nutrients. The inputs used for the cotton was below the recommendation. In the economic point of view farmers should allocate their more land resources in the cultivation of cotton than Sugarcane in study area.

2.39
Acceptability of cot bag among farmwomen engaged in cotton picking: A Haryana study

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Rural women in Haryana are involved in most of the agricultural operations, *viz.,* transplanting, weeding, harvesting and post-harvest activities like picking and plucking. Cotton picking is a tedious job exclusively handled by women folk in Haryana. A study was conducted on 200 rural women working at cotton fields in four villages, *viz.,* Kirtan, Ladwa, Talwandi Rana and Sadalpur of Hisar district and four villages *viz.,* Ukhalchanakot, Sikanderpur, Bajitpur and Jondhi of Jhajjar district in Haryana. Schedule was developed to collect data on socio-economic profile of the respondents. Cotton picking bag developed by College of Home Science, CCSHAU, Hisar was tested on all the 200 women undergoing one hour of cotton picking activity. During the study, time and activity profile, work output and acceptability of the cot bag was assessed. Women performed cotton picking activity between 50-60 days in a year. The women reported very severe pain in palm, wrist, fingers, neck and shoulders. The results revealed that by using conventional *jholi*/bag, the rural women could pick up to 25-30 kg of cotton in 7-8 hrs. and earn about Rs. 300- 350/- per day but by using cotton picking bag they could pick 35-40 kg. of cotton in 7-8 hour, thus earning about Rs. 400-550 per person per day. Output of cotton picking was found to be more with the help of cot bag. Majority found it to be highly acceptable (85.50 per cent). Overwhelming majority (92.00 per cent) perceived that using cot bag reduced pain in their shoulders (93.00 per cent), backache (96.00 per cent) and pain in hands (52.50 per cent) and overall it helped in reducing the drudgery of women to a considerable extent. Adequate rest pauses coupled with training on use of proper body postures along with light exercises for back and shoulders are required to delay the onset of fatigue. Keeping in view the high acceptability of cot bag among rural women its promotion through KrishiVigyanKendras is suggested through vocational trainings imparting knowledge on drafting, cutting and stitching of cot bags.

CROP PROTECTION AND BIOSAFETY

3.1

Collection, isolation and characterization of soil borne pathogen causing root/stem rot disease complex in Punjab

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Cotton, popularly known as the "White Gold" is an important *kharif* crop of the south western region of Punjab. Biotic and abiotic constraints are the major hindrances in the production of the cotton crop. Among the biotic constraints, apart from the cotton leaf curl virus disease, incidence of root/ stem rot disease complex caused by the soil borne plant pathogens were noticed in the Bathinda and Fazilka district. Symptoms of shrinking of stem and later on shrinking part becomes charcoal black in colour, Blackening on the superficially layer of the stem or rotten of the root or stem disease complex were noticed. Incidences were usually noticed after 30 DAS at the time of first irrigation or rainfall. During 2019, at the time of cotton cropping season, monitoring and survey of the cotton crop, incidence of root/stem rot disease complex were noticed. Diseased samples from the different locations of the Bathinda and Fazilka district were collected and isolated on Potato Dextrose Agar media. Identification of the cultures were done on the basis of morphological characteristics. For further study, molecular characterization was done by amplification of the ITS region of rDNA of the fungal isolates by using ITS 1 and ITS 4 primers. Identification of *Fusarium* and *Rhizoctonia* was established in the cultures of different locations. The exprimental trials will be conducted to prove the pathogenicty by Koch Postulates.

3.2

Evaluation of fungicides for the management of sooty mould of cotton

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Sooty mould caused by *Capnodium spp.* in cotton is one of the serious emerging problems in Haryana that caused considerable economic losses to yield and quality of cotton. Therefore, an experiment

was laid out to find out suitable control measures for sooty mould disease with nine treatments including control. For this, cotton hybrid US-51 BG-II was sown during *kharif,* 2017 and 2018 in three replications in R.B.D design with spacing 100x45 cm at CCS HAU Cotton Research Station Sirsa. All the recommended agronomical practices were followed for raising a good crop.

Perusal of data indicated that all the treatments were significantly effective in controlling the sooty mould disease as evidenced from the lesser per cent disease incidence as compared to control. The lowest sooty mould disease intensity was observed 13.34% in *kharif*, 2017 and 14.33 in *kharif*, 2018 in the treatment copper oxychloride 50 WP @ 2.25g/l followed by copper oxychloride 50 WP @ 1.75 ml/l and further @ Propiconazole 25 EC @ 1ml/l Maximum seed cotton yield (2030 kg/ha in *kharif,* 2017 and 2035 kg/ha in *kharif,* 2018) was recorded in the copper oxychloride 50 WP @ 2.25g/l which is significantly higher than control and other treatments. Maximum disease reduction was also recorded in the treatment copper oxychloride 50 WP @ 2.25g/ litre in both the years of experiments. So it is evident that copper oxychloride 50 WP is most effective in managing this disease.

3.3
Efficacy of insecticides against sucking pests of cotton

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The field experiment was conducted during *kharif* 2015-2016 in the research farm of the All India Coordinated Research Project on Cotton under the Regional Research and Technology Transfer Station (OUAT), Bhawanipatna situated in the western undulating agro climatic zone of Odisha to study the efficacy of insecticides against sucking pests of cotton. The trial was laid out in randomized block design with three replications at the spacing of 90 x 60 cm taking DCH 32 as the test hybrid. Insecticides treatments *viz.*T_1: Buprofezin (25%SC) @ 250 g a.i/ha, T_2: Flonicamid (50% WG) @ 75 g a.i/ha, T_3: Flonicamid (50% WG) @ 100 g a.i/ha, T_4: NSKE (5%) @ 5 ml/l, T_5: Diafenthiuron (50% WP) @ 300 g a.i/ha, T_6: *V.lacanii* @ 10 g/l, T_7: *M.anisopliae* @ 10 g/l and T_8: Control (unsprayed) were evaluated against sucking pests of cotton. Three sprays were taken up against sucking pests to enhance the efficacy. Five plants from each plot were selected randomly for recording observations on sucking pests. The observations were recorded one day before spray and on 7^{th} day after each spray.

All treatments performed better over the control. Significant differences were observed for population of sucking pests in cotton for different treatments under study. The lowest population of jassids

(1.19 / 3 leaves), aphids (2.17 / 3 leaves) and thrips (0.61 / 3 leaves) were recorded in T_3 (Flonicamid (50% WG) @ 100 g a.i/ha) followed by T_2 (Flonicamid (50% WG) @ 75 g a.i/ha) with jassids (1.83 / 3 leaves), aphids (2.47 / 3 leaves) and thrips (0.94 / 3 leaves) and T_5 (Diafenthiuron (50% WP) @ 300 g a.i/ha) with jassids (2.28 / 3 leaves), aphids (2.61 / 3 leaves) and thrips (0.94 / 3 leaves). Maximum seed cotton yield of 24.73 q/ha was recorded in T_3 (Flonicamid (50% WG) @ 100 g a.i/ha) which was statistically *at par* with T_2 (Flonicamid (50% WG) @ 75 g a.i/ha) with 23.79 q/ha, T_5 (Diafenthiuron (50% WP) @ 300 g a.i/ha) with 23.33 q/ha and T_1 (Buprofezin (25%SC) @ 250 g a.i/ha) with 21.73 q/ha. T_3 (Flonicamid (50% WG) @ 100 g a.i/ha) recorded the highest B: C ratio (2.50) followed by T_2 (Flonicamid (50% WG) @ 75 g a.i/ha) with 2.47 and T_1 (Buprofezin (25%SC) @ 250g ai/ha) with B:C ratio of 2.36.

3.4

Bio efficacy of Sulfoxaflor (50% WG) against sucking pest fauna its effect on natural enemies and phytotoxicity on cotton

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Studies conducted during *kharif* 2015 and 2016 at research farm of Regional Agriculture Research Station, Khandwa (M.P.). There were seven treatments *i.e.*, untreated control, Sulfoxaflor (50% WG) 75 g a.i./ha, Sulfoxaflor (50% WG) 90 g a.i /ha, Sulfoxaflor (50% WG) 100 g a.i./ha, Flonicamid (50% WG) 75 g a.i./ha, Buprofezin (25% SC) 250 a.i. /ha and Dinotefuran (20% SG) 30 g a.i. /ha. These treatments were tested under randomized block desigh (RBD) with three replications against, *Amrasca biguttula biguttula, Thrips tabaci, Aphis gossypii and Bemisia tabaci* and also observed the phytotoxicity along with impact on natural enemies, like Coccineliid beetle and Chrysoperla populations. Seeds of cotton were sown in both experimental years. All the treatments were sprayed when target insect pests incidence was above economic threshold level (ETL) and second application of spray was applied 15 days after first application. Phytotoxicity was recorded after both spray treatments on the basis of visual observations. Ten plants in each treatment were observed at 1,3,5,7,10 and 15 days after each spray on wilting, vein clearing , necrosis, epinasty, hyponasty on the grading of 0-10 point Scale. The highest- control of *Amrasca biguttula biguttula, Thrips tabaci, Aphis gossypii and Bemisia tabaci* recorded in treatments Sulfoxaflor (50% WG) @ 100 g a.i./ha and Flonicamid (50% WG) @ 75 g a.i/ha after each application of both years 2015-2016. There was no significant effect of Sulfoxaflor (50% WG) @ 100 and 200 g @ a.i./ha on the population of *Chrysoperla carna* and *Coccinella spp.* after 5 days of two spray treatments in both years. There was no phytotoxicity symptoms like epinasty ,

hyponasty, chlorosis ,necrosis, vein clearing and stunting were observed on cotton plants after application of Sulfoxaflor (50% WG) @ 100 and 200 g @ a.i./ha on the population of *Chrysoperla carnea* and *Cocccinella spp*. after 5 days of two spray treatments in both years. All insecticidal treatments recorded significantly more seed cotton yield in comparison to untreated control. Amongst the insecticidal treatments Sulfoxaflor (50% WG) @ 100 g.ai. /ha recorded maximum yield of 1303.33 Kg/ha.

3.5
Relationship of weather parameters with incidence of pink bollworm (*Pectinophora gossypiella*) in cotton

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Studies were conducted on seasonal incidence of pink bollworm in Nanded and Parbhani Districts of Maharashtra during 2017-2018 and 2018-2019 under CROPSAP Project. The incidence of Pink bollworm (*Pectinophora gossypiella*) started in first week of August during 2017-2018 and 2018-2019 in both the districts. In Parbhani district pink bollworm population reached its peak in 52nd SMW during 2017-2018 and in 32nd SMW during 2018-2019. Pink bollworm population reached its peak in 51st SMW during 2017-2018 and in 33rd SMW during 2018-2019 in Nanded district. The correlation between weather parameters and larval population of pink bollworm indicated that Minimum temperature showed significantly positive correlation with pink bollworm larvae at 5 per cent level in Parbhani district during 2017-2018. However Morning as well as evening relative humidity showed significantly positive correlation with pink bollworm larvae at 1 per cent level in Parbhani district during both the years. In Nanded district during both the years the correlation between minimum temperature as well as evening relative humidity were significantly positive with population of pink bollworm larvae at 1 per cent level. The multiple regression analysis indicated that the total influence of all the weather parameters were 56.80 per cent and 50.70 per cent during 2017-2018 and 2018-2019 respectively in Parbhani district. However the total influence of all the weather parameters were 86.80 per cent and 83.30 per cent during 2017-2018 and 2018-2019 respectively in Nanded district.

3.6

Recent status of the cotton leaf curl virus disease severity in cotton in Punjab

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ABSTRACT

Cotton leaf curl virus disease (CLCuD) caused by Gemini virus and transmitted through whitefly (*Bemisia tabaci*) is one of the major disease affecting the yield and productivity of the cotton in the South Western Region of Punjab. The studies were undertaken during the monitoring and surveillance of the cotton crop in the farmer's field of Bathinda and Fazilka district in the year 2017, 2018 and 2019.The number of locations were visited in the Bathinda and Fazilka district. During the monitoring and surveillance, it was observed that only the *Bt* cotton hybrids were raised in the farmer's field. Maximum area were covered under the Rasi seeds having the variety *viz.,* RCH 773 BG II and RCH 776 BG. Incidence of the Cotton leaf curl virus disease (CLCuD) were observed in most of the locations in both the districts. In Bathinda district, disease severity of CLCuD were found to be higher in the year 2017 and later on gradually reduced in 2018 and 2019, respectively. In Fazilka district, disease severity of CLCuD were found to be higher in the year 2017 and later on gradually reduced in 2018 but in comparison to 2018 in the year 2019, disease severity of CLCuD were found to be at higher range. In comparison between both the districts, disease severity of CLCuD were found to be higher in the Fazilka district as compared to Bathinda district. The reason regarding the higher disease severity of CLCuD in the Fazilka district, might be due to the change in the climatic conditions, Agro-climatic situations, delayed sowing and variability of the strains of the CLCuD. Another major important reason is that the intercropping of the cotton between the citrus orchards and intercropping of the cotton crop with cucurbits were observed. The cotton crop were also raised adjoining Guara and Okra(bhindi) crop. In Bathinda district, only the monocropping of the cotton crop were seed and the cotton field adjoning *Guara* and okra(*bhindi*) were not observed.

3.7
Bio efficacy of newer insecticide against bollworm complex in cotton

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The Bio efficacy of newer insecticide against bollworm complex in cotton were studied during *kharif* 2018-2019 was conducted on the farm of Department of Agricultural Entomology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The results revealed that application of Chlorantraniliprole 18.5 per cent SC proved effective in recording minimum green fruiting bodies damage as well as per cent shed material, which was *at par* with emamectin benzoate 5 per cent SG, spinosad 45 per cent SC and thiodicarb 75 per cent WP.

3.8
Incidence and dynamics of sucking pests on transgenic cotton is influenced by the prevailing abiotic factors

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Transgenic cotton in north Indian plains faced worst ever crisis due to infestation of sucking insects in 2014-2015. This resulted in reduced production, acreage and huge economic losses to cotton growers during 2015-2016. As we are well aware that global warming and disturbances/ variations in abiotic factors influence the insect-pests/host biology and ecology. Therefore we studied the dynamics and seasonal incidence of whitefly and jassids on transgenic cotton in southwestern Punjab during *kharif* 2016, 2017 and 2018. Also the correlations to different abiotic factors were worked out. Schematic weekly surveillance was conducted in the selected 6 different blocks from the studied region. Five villages/block and from each village five different cotton fields were surveyed and the incidence of whitefly and jassids recorded at weekly intervals as per standard protocol. The

data so collected were averaged and analyzed for various inferences. The results revealed that the average whitefly population ranged from 1.16 – 18.0, 0.84 – 17.22 and 0.63 – 3.0 adults/3 leaves with its peak at 36th, 32nd and 30th SMW for the cropping season 2016, 2017 and 2018, respectively. Moreover, yearly average jassid population ranged between 0.0 – 4.5, 0.0 – 3.2 and 0.0 – 10.7 adults/ 3 leaves with its highest value at 30th, 27th and 30th SMW for cotton growing period of 2016, 2017 and 2018, respectively. Whitefly population showed a non-significant correlation with rainfall and maximum temperature, while positively correlated with minimum temperature and relative humidity. Moreover, minimum relative humidity and rainfall showed significantly positive correlation for jassid dynamics. The lowest whitefly population was observed during cotton crop period of 2018 due to lower range of relative humidity and lesser cloudy days than rest of the years which disfavored the whitefly incidence.

3.9

Effect of intercropping on the incidence of spotted bollworm, *Earias* spp. in *desi* cotton, *Gossypium arboreum* L.

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Cotton is the most important cash crop of India, which have worldwide significance. Bollworms *viz.,*, spotted bollworm (*Earias vittella* Fabricius), (*Earias insulana* Boisdual), American bollworm (*Helicoverpa armigera* Hubner), and pink bollworm (*Pectinophora gossypiella* Saunders) are major bollworms of cotton and among these bollworms, spotted bollworm cause considerable losses in cotton, their heavy infestation reduces the crop yield to a great extent. Due to continuous and indiscriminate use of the synthetic insecticides several problems like resurgence, outbreak and resistance have been reported. Intercropping is a eco friendly practice and is significant because of higher profit and stabilized yield advantage, especially under adverse weather conditions. An experiment was conducted at experimental area of Department of Entomology, CCS Haryana Agricultural University, Hisar, India, during 2016 and 2017 in *desi* cotton variety named HD-432. Four intercrops were taken *i.e.* Sesame (HT-1), Pigeonpea (Paras), Sorghum (HC-171) and *Bajra* (HHB-67i). There were nine treatments (Cotton + Sesame 1:1, Cotton + Sesame 2:1, Cotton + Sesame 3:1, Cotton + Pigeonpea 1:1, Cotton + Pigeonpea 2:1, Cotton + Pigeonpea 3:1, Cotton + Sorghum as border crop, Cotton + *Bajra* as border crop and Sole Cotton and three replications in each treatment. Among the

treatments lowest incidence of spotted bollworm was recorded in cotton-sesame 1:1 intercropping (8.57%) which was followed by cotton-sesame 2:1 intercropping (9.62%), cotton-sesame 3:1 intercropping (10.05%), cotton pigeonpea 1:1 intercropping (10.71%), cotton-pigeonpea 2:1 intercropping (10.81%), cotton intercropped with *bajra* as border crop (10.86%), cotton-pigeonpea 3:1 intercropping (10.90%), cotton intercropped with sorghum as border crop (11.56%) and highest incidence was recorded in sole cotton (12.90%).

3.10
Effect of biorational management practices on pink bollworm damage in *Bt* cotton

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The present investigation entitled was carried out during kharif of 2018-2019 on, the research farm of Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The field experiment was laid out in Randomized Block Design with nine treatments and three replications. The results revealed that minimum green fruiting bodies damaged was recorded in treatment T_6 *i.e.* 0.68 per cent where weekly destruction of rosette flower along with five releases of trichocards @ 3 cards/acre alternated with four sprays of Azadirachtin @ 10 ml/10 l at 10 days interval starting at 50 DAE were carried out whereas, maximum 2.01 per cent was recorded in untreated control. Same trend was observed in case of green boll damaged where minimum green boll damaged recorded due to pink bollworm was 9.58 per cent and maximum 32.92 per cent was observed in control. Overall minimum pink bollworm damage was recorded in treatment T_6 *i.e.* 10.83 per cent and maximum 52.41 per cent was recorded in untreated control at the time of harvest. Maximum seed cotton yield (12.53 q/ha) was also recorded in treatment T_6 whereas minimum 6.36 q/ha was recorded in control T_9.

From the overall data it was concluded that weekly destruction of rosette flower + five releases of trichocards @ 3 cards/ac alternated with four sprays of Azadirachtin @ 10 ml/10 l at 10 days interval starting at 50 DAE provided maximum protection from pink bollworm damage in *Bt* cotton. As the number of releases and sprays decreases pink bollworm damage increases. However, on the basis of Incremental cost benefit ratio weekly destruction of rosette flowers + five releases of trichocards @ 3 cards/ac alternated with four sprays of Azadirachtin @ 10 ml/10 l at 10 days interval starting at 50 DAE were found economical.

3.11

IDM modules for the management of bacterial leaf blight and Alternaria leaf spot disease in natural condition under south Gujarat region of India

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Cotton is grown all around the globe, and is traded internationally as well. Cotton is a white fibrous agricultural product that has a wide variety of uses, from textile production, to creating paper, to producing oil and food products. Plant diseases are measured as an important biotic constraint, which significantly leads to crop losses worldwide. "Integrated Disease Management", which combines physical, biological, cultural and chemical control strategies in a holistic way rather than using a single component strategy. It also involves the selection and application of a harmonious range of control strategies that minimize losses and maximizes the returns. Here, in this experiment different modules were taken and their significance was tested in the MCRS, NAU, Surat. Treatment of module 6 (Seed Treatment - PF CICR @ 10 g/ kg of seed + Soil Application of *Trichoderma viride* @ 2.5 kg/ ha TV- TNAU1 in 250 kg of vermicompost or FYM and foliar spray with Kresoxim methyl @ 0.0443 per cent followed by COC (0.2 %) + Streptocycline (0.01 %) with two sprays first from the initiation of the disease and second after the interval of 15 days recorded the lowest incidence of Bacterial leaf blight and Alternaria leaf spot diseases of cotton and recorded the highest seed yield in module 6 (2589.44 kg/ha) followed by module 5 with 2350.22 seed yield kg/ha.

3.12

Analysis of weather correlates of the incidence of Alternaria Leaf Blight in cotton

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Alternaria leaf blight (*Alternaria macrospora*) has been reported to cause about 20-30 per cent losses in seed cotton yield. In some cases, the disease incidence is so heavy which will force farmers to

plough the field as well. The weather parameters play a pivotal role in bringing diseases including ALB in cotton. A study was conducted to predict the contribution of weather parameters towards incidence of ALB in cotton using the meteorological data pertaining to five parameters for a decade (2007 to 2016). The Per cent Disease Index for ALB calculated for 10 years under study was plotted and comparative analysis indicated that the year 2013 experienced the maximum infection of ALB followed by 2009, 2011 and 2010. The minimum infection of ALB was experienced during 2007, 2008 and 2012. In other years under study, the infection was found to be medium. The regression analysis to find out the contribution of selected five weather parameters towards PDI revealed that 88.50 percentage change in PDI was explained by the selected five weather parameters (R^2=0.885). Among the predictor variables, only one variable namely RH morning was found to be positively significant at 1 per cent level of significance and contributed to the PDI. This implies that the increase in morning RH would increase the PDI of ALB in cotton. The regression equation could be interpreted that, when all the selected weather parameters are kept constant except RH Morning, one unit increase in RH Morning would increase the per cent disease index by 0.514 units. Significant negative correlation was observed for maximum temperature and minimum temperature with per cent disease intensity, while morning relative humidity and sunshine hours were positive and significantly correlated. The regression analysis of PDI indicated that for every one per cent increase in morning relative humidity there was corresponding increase of 0.88 in per cent disease index of ALB and suggests protective measures are to be taken up with recommended fungicides like mancozeb and pyraclostrobin.

3.13

Population dynamics of pink bollworm, *Pectinophora gossypiella* (Saunders) with relation to weather factors under unprotected condition in cotton

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The field experiments were conducted to study the population dynamics of pink bollworm *Pectinophora gossypiella* (Saunders) in cotton during summer 2018 (February to July) and winter 2018-2019 (August-January) at Cotton Research Station, Srivilliputtur. The experiment plot was kept in unprotect condition throughout the cropping period. Observations on rosette flower damage, number of pink bollworm larvae/plant, locule damage were recorded by randomly selecting 20 plants from one month

after sowing at weekly interval and monitoring the pink bollworm adult was also recorded in sex pheromone trap. The recommended agronomic practices were carried out. Data on weather parameters were obtained from the Meteorology unit, Cotton Research Station, Srivilliputtur. The relationship between weather parameters and pink bollworm incidence was established by using simple correlation coefficient analysis.

The revealed that the activity of pink boll worm adults was found throughout the period during summer 2018 and winter 2018-2019. In pheromone trap, maximum attraction was recorded during 25th SW (9.00 nos/trap/week) in summer and 52nd SW (11.00nos/trap/week) in winter. The percentage of rosette flower was high during the 15 th SW (14.80 per cent) in summer and 47th SW (20.80 per cent) in winter. The maximum number of larvae was recorded in the 26th SW (11 larvae/ 20 green bolls) in summer and 52nd SW (11.00 larvae/20 green bolls) in winter. The locule damage was high during 29th SW at harvest (17.22 per cent) and 5th SW at harvest (14.00 per cent) in winter. The trap catches of pink bollworm adults was positively correlated with minimum temperature and negatively correlated with other parameter like maximum temperature, relative humidity and rainfall. The rosette flower damage was positively correlated with minimum temperature, relative humidity and rainfall. The number of pink bollworm larvae per plant and percentage of locule damage were positively correlated with maximum temperature.

3.14

Seasonal incidence of major insect pests and their correlation with weather parameters in cotton

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Cotton is one of the important cash crop of farmers community in India and its production affected by insect pest. In order to determine the seasonal incidence of major insect pest of cotton and its correlation with weather parameters these studies carried out was department of Agricultural Entomology, VNMKV, Parbhani . The incidence of aphids was highest (20.4 aphids/three leaves) during 40th MW. Jassid highest population (21.6 jassids/three leaves) was observed during 37th MW. Thrips reached highest incidence (30.20 thrips/three leaves) in 41rd MW. Highest incidence or population of whitefly (24.50 whiteflies/three leaves) was noticed during 37nd MW. The larval population of *Helicoverpa armigera* was highest (5.40 larvae/plant) in 43th MW. Per cent rosette flowers

due to *P. gossypiella* was highest (27.17 per cent) in 41th MW. Larval population of *P. gossypiella* was highest (25 larvae/ 20 green boll) in 48th MW and per cent green boll infestation due to *P. gossypiella* is highest (125 per cent) in 48th MW. Simple correlation studies revealed that weather parameters *viz.,*, Aphid population was negatively significant with the rainfall and maximum temperature. The Jassid population was negatively significant with the maximum temperature. Thrips population was negatively significant with the rainfall, maximum temperature, morning relative humidity as well as wind velocity.

Whitefly population with weather parameters in cotton showed that negatively significant with the rainfall and maximum temperature. The *H. armigera* population was negatively non-significant with the rainfall, evening RH, and wind velocity. The data on rosette flowers by *P. gossypiella* showed that positively non-significant with rainfall, minimum temperature, bright sun shine, and wind velocity.

3.15
Validation and impact of IRM/IPM strategies for the management of pink bollworm in *Bt* cotton in Bharuch district of the Gujarat state

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The centrally sponsored network project NFSM:CC:Cotton: Dissemination of pink bollworm management strategies was implemented to educate cotton farmers for pink bollworm management strategies formulated by ICAR-CICR in Bharuch district, Gujarat. The FLDs on pink bollworm management strategies under Insecticide Resistance Management (IRM) umbrella (50 nos. of 1 acre) was allotted in irrigated tract of Valia Taluka considering previous year infestation and bench mark survey during 2018-2019. The recommended package validated was timely sowing of short duration hybrids, refuge incorporation, monitoring population through pheromone traps, participatory pest scouting, window based selection of insecticides and application at ETL populations, timely picking, marketing, crop termination and residue management as well as follow up management at ginning mills. Amongst sucking pests population aphid, thrips and leafhopper had crossed ETL 1 time and whitefly and mealybug remained below ETL during the season in IRM plots whereas aphid, thrips and leafhopper crossed ETL 4, 1 and 5 times, respectively and whitefly and mealybug remained below ETL in non IRM plots. Sucking pest's required average 2.90 sprays in IRM plots and average

3.00 sprays in non IRM plots. For pink bollworm management, 2.20 and 2.70 sprays were targeted by farmers under IRM and non IRM plots condition, respectively. Seed cotton yield varied from 830 to 979 kg/ac and 810 to 968 kg/ac under IRM and non IRM condition, respectively. The net return was found higher in IRM plots (Rs. 21,500 to 27,875/ac) than the non IRM (Rs. 18,740 to 25,663/acre). The project impacted the knowledge update and skill enhancement of various stakeholders directly or indirectly and helped in reducing yield loss and quality cotton production in the region.

3.16

Assessment of yield losses due to mealybug (*Phenaccocus solenopsis* Tinsley) infestation in the cotton farmers' field of south Gujarat

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Investigation on incidence and estimation of yield losses due to mealybug (*Phenaccocus solenopsis* Tinsley) was carried out on cotton farmers' fields of South Gujarat during 2015-2016 to 2017-2018. Total of 21 villages of two districts were surveyed for assessment of losses due to mealybug infestation/damage during the harvesting seasons (October to December). The average intensity of mealy bug was 9.32 and 19.93 per cent within 8.50 and 16.56 per cent infested plants in villages of Umarpada and Olpad taluka of Surat district, respectively. Whereas it was 13.84, 16.50, 21.02 and 21.15 per cent within 12.13, 14.11, 17.33 and 17.44 per cent infested plants in villages of Hansot, Amod, Valia and Bharuch taluka of Bharuch district, respectively. The management practices followed by farmers and the data on natural parasitism of mealybug by *Aenasius bambawalei* Hayat was also recorded in the surveyed villages which indicated per cent parasitism in the range of 6.56 to 9.21 in Olpad and 4.73 to 7.08 per cent in Umarpada taluka whereas it was 4.90 to 11.07 in Hansot, 6.79 to 13.14 in Amod, 10.53 to 14.60 in Valia and 8.00 to 12.61 per cent in Bharuch taluka. The yield loss due to mealybug was assessed based on prevalence of plants having four grade injuries and was estimated to be 0.69 to 1.49 per cent in villages of Olpad taluka whereas it was nil in villages of Umarpada taluka. In Bharuch district, it was 0 to 0.74, 0.68 to 2.63, 1.07 to 2.44 and 1.87 to 2.97 per cent in villages of Hansot, Amod, Bharuch and Valia taluka, respectively. Under farmers' practices, the overall loss estimated was 1.07 per cent worth of Rs. 4800/- per ha comprising of Rs. 2800/- for seed cotton yield and Rs. 1987 for mealybug management.

3.17
Assessment of cotton disease in advanced yield trial line

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A comprehensive investigation was conducted to find out occurrence of cotton diseases in Advanced Yield Trial Line with their causal agents . The assessment was conducted at Cotton Research, Training and Seed Multiplication Farm Sreepur, Gazipur in 2017-2018 . It was found that cotton seedlings are attacked by four leaf spots caused by *Alternaria alternata, Curvularia lunata, Helminthosporium* sp. and *Rhizoctonia solani*. During investigation, only bacterial disease identified named angular leaf spot or bacterial blight caused by *Xanthomonus campestris* pv. *malvacearum*. Seedling mortality is common problems due to seedling disease complex caused by *Colletotrichum gossypii, Fusarium oxysporum, F. moniliforme, Rhizoctonia solani* and *Macrophomina phaseolina*. *Rhizoctonia solani* . Various type Boll rot diseases was found and the causal organisms were *Fusarium oxysporum*, *Colletotrichum gossypii* and *Diplodia* spp. The results revealed that boll rot disease index varied from genotype to genotype.

3.18
Occurrence of natural enemies in *Bt* and non-*Bt* cotton in the western undulating zones of Odisha

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The field experiment was carried out during *kharif* 2013 and 2014 at Regional Research and Technology Transfer Station (RRTTS), Bhawanipatna, Kalahandi, Odisha on population dynamics of natural enemies on *Bt* cotton genetically engineered with incorporation of the Cry1Ac + Cry2Ab genes and non *Bt* cotton raised following recommended package of practices. Six lady bird beetle species *viz.*,, *Cheilomenes sexmaculata* (Fabricius), *Anegleis cardoni* (Weise), *Coccinella transversalis*

Fabricius, *Exochomus nigripennis* (Erichson), *Micraspis univittata* (Hope), *Harmonia octomaculata* (Fabricius) (Coccinellidae: Coleoptera) predominantly noticed throughout the season from 34th SMW to 52nd SMW with varying degree of population in *Bt* and non-*Bt* cotton. The mean grub and adult population of coccinellids reached the peak 1.78/ plant during 39th SMW and 1.82/plant during 37th SMW in *Bt* and non-*Bt* cotton respectively. The mean maximum egg laying by the green lacewings, *Chrysoperla carnea* Stephens (Chrysopidae: Neuroptera) was recorded during 48th SMW (0.40/plant) and 38th SMW (0.44/ plant) in *Bt* and non-*Bt* cotton. The weekly mean population of predatory Syrphid maggots, *Ischiodon scutellaris* (Fabricius) (Syrphidae: Diptera) reached the peak (0.38 and 0.56/ plant in *Bt* and non-*Bt* cotton respectively) at 37th SMW. Predatory pentatomid bug, *Eocanthecona furcellata* Wolff (Pentatomidae: Hemiptera) population attained peak in *Bt* (0.12 /plant) and in non-*Bt* (0.24/plant) during 37th and 42nd SMW.The larval parasitoid, *Apanteles syleptae* Ferriere (Braconidae: Hymenoptera) appeared on non *Bt* cotton only with a mean population density of 0.62/ plant at 38th SMW. Mixed population of five spider species *Thomisus onustus* Walckenaer (Thomisidae: Araneae), *Oxyopes salticus* Hentz (Oxyopidae: Araneae), *Oxyopes birmanicus* Thorell (Oxyopidae: Araneae), *Peucetia viridians* Hentz (Oxyopidae: Araneae) and *Araneus sp.* (Araneidae: Araneae) were prevalent in both *Bt* and non-*Bt* cotton from 32nd SMW to 52nd SMW in both the years. The weekly mean population of spiders reached maximum (1.42/ plant) at 41st and (1.38/ plant) at 42nd SMW in *Bt* and non-*Bt* cotton respectively.

However, the natural enemies occurred on both *Bt* and non-*Bt* cotton synchronizing with the occurrence of their respective prey population difference remaining non-significant.

3.19

Sudden wilt in cotton: Prominent factors contributing to its occurrence in north India

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The occurrence of sudden wilt problem in cotton at 125-160 days after sowing in north India is increasing since last one decade. It has been established th*at par*awilt/ sudden wilt is a physiological disorder in which the soil plant atmosphere continuum is broken due to adverse environmental factors like soil saturation which results in poor root growth and reducing oxygen influx as a principal cause of injury to roots and the shoots. However, the studies on primary factors responsible for occurrence of this situations in cotton fields in North India are merely availale. Hence, to understand

the factors responsible for sudden wilt, field data were collected during the month of July to November 2017 and 2018 from Rajasthan, Haryana and Punjab. The root rot incidence was recorded to be 0-75 per cent in Haryana, 0-15 per cent in Rajasthan and 0-5 per cent in Punjab during 2017-2018. However, during 2018-2019 similar types of wilting problem were found associated withroot rot (15.8 per cent), root rot and nematode infection (28.3%), root rot and termites (7.2%) and in fungal foliar spots (26.5%). Data from farmers fields also indicated that among all, 35.1 per cent farmers have followed three combined practices- *i.e.* cotton-wheat cotton cropping system, no deep ploughing and early irrigation. Among such fields, root rot and nematode infection (32.4%), root rot (10.8%), root rot and termite (8.1%) and fungal foliar spots (24.3%) were observed, while 29.7 per cent cotton field were observed with the sudden wilting problem. Among all, 29.7 per cent cotton fields showed typical sudden wilting from the month of September onwards. These 29.7 per cent fields were practiced no deep ploughing, cotton-wheat-cotton cropping system more than the past 5 years and early irrigation (before 30 DAS). The soil EC and pH in these fields were ranged between 2.5 to 4.5 dS/m and 7.6 to 7.9, respectively. The root depth in these fields was ranged between 10-20 cm with higher root density in first 10 cm layer 21-50 per cent fields and 20-30 cm root depth in 50-67.5 per cent fields. These practices and soil health situations appeared to be the prominent factors contributing to the poor root development and occurrence of sudden wilt and also enhanced vulnerability of cotton crop to biotic problems such as root rot, nematodes, fungal foliar spots (71.4%), and termites/root rot (28.6%). Hence, to manage these problems, a large and deep root system should be developed as quickly as possible and shoot growth should be controlled before the plants enter the reproductive growth stage so as to achieve potential yield.

3.20

Seed health status of cotton genotypes in western undulated zones of Odisha

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Cotton is grown near about 70,000 hectares in western undulating zones of Odisha particularly in Kalahandi and Nuapada. The major growing districts of Odisha are Kalahandi,Nuapada, Raygada and Bolangir. The productivity of cotton is 495 kg lint / ha where as the seed yields is 15q/ha in Odisha. There are several types of fungi infecting cotton seed which reduces seed quality and its

health. Ten nos. of cotton genotypes were collected from RRTTS, Bhawanipatna and one genotype from Nuapada and tested under in-vitro (Laboratory) condition to investigate its seed health as well as seed quality status in order to manage the crop diseases and get information on planting value. Average seed moisture content, germination (%), physical pure seed (%), SVI-I, SVI-II, EC and seed borne mycoflora infection as well as infestation were under taken for study in laboratory of Seed Science and Technology and Plant Pathology, College of Agriculture, Bhawanipatna.Significant differences of mean in seed moisture content ranged (10.2-12.4 %), physical pure seed (81.4-98.6 %), seed germination (64-94 %), seedling length (16.39-18.42cm), seedling dry weight (0.529-0.582g), SVI-I (1048.96-1731.48) and SVI-II (33.85-54.71). A total of 5 fungi belonging to different groups were recorded from the samples of Kalahandi and Nuapada districts *viz.,, Aspergillus niger* (24 *%), A. flavus* (16 %), *Pencillium spp.*(20 %), *Curvularia lunata* (16 %), *Alternaria* (12 %) and *Fusarium* (12 %). *Among the fungal mycoflora Aspergillus niger , Aspergillus flavus and Curvularia are found in most of the genotypes.* Most of the genotypes revealed significantly lower in quality parameters than the IMSCS specified for Cotton. Therefore, it is recommended that freshly harvested seeds should be well dried to safe moisture content (9.0 %) with proper seed treatment to protect from seed mycoflora infection.

3.21
Status and future strategies for management of Cotton Leaf Curl Virus vector

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Cotton is an important cash crop in Indian agricultural, industrial & economic development. It is known as the king of fibres and is also called **"White Gold"** playing a key role in many socio-economic aspects of the world. In India, cotton is grown in north western states of Punjab, Haryana and Rajasthan but its cultivation is severely affected by plant viruses and among them member of the family *Geminiviridae* causing cotton leaf curl virus (ClCuV) is the most important. Naturally infected cotton exhibits symptoms of severe leaf curling, vein thickening, and enations. It is transmitted by whitefly, *Bemisia tabaci*. Apart from cotton, the virus infects alternate hosts like tomato, tobacco, datura, okra and china rose etc. that act as reservoir hosts for its spread from one season to the other through whitefly. The identification of weeds carrying CLCuV virus and its timely detection can help in timely rouging out weed plants to prevent further spread of the virus.

During the year 2016-2017 and 2017-2018 early sown cotton variety (HS-6) in the second fortnight of April was found to be more appropriate to minimize cotton leaf curl viral disease resulting in less disease incidence and whitefly population as compared to late sown crop in Hisar, Haryana. The correlation with weather parameters (Temp and RH) was found to be positively correlated with whitefly population. Although organophosphate and carbamate insecticides are used for the vector control which targets the acetylcholine esterase (AChE) a key enzyme in neurotransmission.The studies with many insect species indicate that resistance to these two classes of insecticides was associated with reduced sensitivity of AChE to insecticides and this can be further worked out as the management strategy for the vector, *Bemisia tabaci* control.

3.22
dsRNA delivery induces gene silencing in *Thrips tabaci* (Thysanoptera:Thripidae)

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Thrips tabaci is one of the most damaging pests of cotton and onion. Due to lack of genomic/ transcriptomic information, not much is known about this insect at the molecular level. The studies were initiated with sequencing of RNA and using the data to identify RNAi pathway genes. Further, feeding RNAi was demonstrated for the first time in this insect. To confirm RNAi, 500ng/µl of dsRNA targeting *SNF* or *AQP* gene was evaluated in membrane feeding assay. The dsRNA feeding led to 16.4 and 14.5 fold decrease in target gene mRNA levels in dsSNF7 and dsAQP fed insects respectively compared to their levels in dsGFP fed insects. Besides affecting mRNA levels, feeding dsSNF7 or dsAQP led to 62 and 72 per cent mortality in test insects compared to 20 per cent in control thrips. Similarly, RNAi pathway genes were identified and knocked down to evaluate the impact on RNAi efficiency of target genes *i.e. AQP/ SNF7.* Pathway genes *Dicer-2, Aubergine* and *Staufen* were knocked down by feeding 500 ng/µl of respective dsRNA resulting in 78.8 and 56.8 per cent decline in mRNA levels of target genes. Co-administration of each of dsDicer-2 and dsAubergine in combination with dsAQP in the diet reduced the knockdown of *AQP* by 42.4-59.8 per cent. Similar reduction in RNAi was achieved after feeding mixture of dsStaufen and dsSNF. In addition, feeding of combination of dsStaufen and dsSNF caused lesser mortality indicating that knockdown of *Staufen* hindered the RNAi of *SNF7* which affected the mortality caused by feeding dsSNF7 in thrips. Comparable results were obtained with knockdown of combination of *Dicer*-2 and *AQP* and reduction in mortality of thrips. The studies confirmed the presence of efficient RNAi in thrips and paved the way for further research on developing RNAi as a management strategy.

3.23

Efficacy of different fungicides against *Macrophomina Phaseolina* (Tassi) Goid causing leaf blight of mungbean

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Macrophomina phaseolina (Tassi) Goid is one of the most damaging seed and soil borne pathogen throughout the world. Under favorable conditions the fungus causes many diseases like leaf blight, damping off, seedling blight, collar rot, stem rot, charcoal rot and root rot in various economically important crops. Mungbean was observed severely affected by leaf blight caused by *Macrophomina phaseolina* (Tassi) Goid in *kharif* as well as during summer season. The pathogen attacks on all parts of plant *i.e.* root, stem, branches, petioles, leaves, pods and seeds. Moreover, seed infection of *Rhizoctoniabataticola* (*M. phaseolina*) ranges from 2.2-15.7 per cent which causes 10.8 per cent in grain yield and 12.3 per cent in protein content of seed in mungbean. The infected seeds act as an important source of primary inoculum for new areas. Soil and seed borne nature of the disease possesses problems for an effective disease management. Therefore, an attempt has been made to introduce management of leaf blight disease on mungbean which have become a serious problem in hampering the production of the mungbean in all growing areas of India.Different systemic and non-systemic fungicides at three different concentration were evaluated *in vitro* against mung bean leaf blight pathogen *Macrophomina phaseolina*. Among the different contact (non-systemic) fungicides evaluated, maximum mean mycelial growth inhibition was observed in Propineb and Mancozeb (99.97%) followed by Captan (85.63 %). Sclerotial formation was also absent in all this three treatments. Out of six systemic fungicides tested, Carbendazim found best with 95.23 per cent mycelial growth inhibition followed by Difenoconazole (75.47%) and Thiophanate methyl (69.49%). Carbendazim showed maximum inhibition of mycelial growth (99.97%) of the test fungus at 250 ppm and 500 ppm concentration. Sclerotial formation was totally absent in all systemic fungicides treatments at 300 ppm concentration except Hexaconazole which was also found poor in growth inhibition.

3.24
Mitigate health problems of pesticide applicators through protective clothing

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Short term problems encountered by farm worker during pesticide applicators identified during survey were: headache, eye irritation, nausea, breathlessness, loss of appetite, dizziness, skin allergy, vomiting and scorching. To overcome these problems, protective clothing/accessories were developed tested on farm workers while spraying on various parameters *i.e.* protection from pesticides/fumes, comfortability, ease of wearing/removing etc. Necessary changes were made as per requirement in the dress and accessories using different kind of fabrics. Physical properties of fabrics were studied as per need of the dress/accessories. Suitability and acceptability of modified protective clothing/accessories was again assessed on selected twenty five respondents after trial of one month considering various parameters. Based on suitability and acceptability, recommended protective clothing/accessories were: Jacket with hood of water resistant fabric having lining of cotton hosiery fabric, chemical resistant mask and nitrile gloves along with goggles/plain glasses and synthetic sports shoes. In case chemical resistant mask is not available cambric was suggested. Recommendations was also made about fabric with specific physical properties. Information about protective clothing was disseminated to 240 farm workers through methodologically developed and duly tested educational package comprising of pamphlets and video film. Farm workers gained knowledge after exposure to pamphlets and video film. The higher impact was observed in terms of gain in knowledge, symbolic adoption and opinion of respondents after exposure to both the medias *i.e.* pamphlets and video film followed by only video and only pamphlets. Thus it was concluded that the prepared educational packages were effective in disseminating knowledge for adoption of protective clothing by the target group.

3.25
First record of the fall armyworm *Spodoptera Frugiperda* (J.E. SMITH) (Lepidoptera : Noctuidae) on *Bt* cotton in India

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The American fall army worm (FAW) *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) native to Americas is one of the important invasive polyphagous pest. Recently, severe incidence of FAW was reported from African countries such as Sao Tome, Nigeria, Benin and Togo in 2016. The occurrence of this new invasive pest was reported for first time on maize from Shimoga district in Karnataka (India) in 2018. It was also recorded in Maharashtra on sugarcane, maize, jowar during 2018. During 2019 kharif season heavy infestation of FAW was observed in Ahmednagar district on maize crop. Fall armyworm (FAW), the pest that has devastated maize crop across the country has shifted to Bt cotton crop for the first time in India, which was recorded during the survey in a farmer's field at Susare village of Ahmednagar district in Western Maharashtra on September 20th 2019 by the team of Scientists from MPKV, Rahuri. The affected cotton crop was growing next to maize crop which was infested by FAW. Due to heavy infestation of FAW on maize the farmer terminated the standing 03 acres maize crop with the help of rotavator. The heavily infested maize crop after termination by rotavator some of the FAW population get killed and majority of the FAW larvae fall in the soil and in stubbles. The defoliated stubbles and soil carried large inoculums of FAW larvae and pupae in the field. The population shifted in the neighbouring Bt cotton field causing extensive damage as the crop was in flowering and boll formation stage. The loss in the FAW infested cotton had crossed the economic threshold level (ETL). The severity of infestation was high on the adjoining to the maize crop, while it was goes decreasing to the opposite end of the field. The half portion of the field adjoining to the maize plot was recorded about 30-40 % plants infested by the FAW. The green boll damage observed in first half plot was 21 per cent and flower damage found to be 20 per cent. While green boll damage recorded in second half plot was 7 per cent and flower damage was 9 per cent. In an average 14 percent green boll damage and 14.5 percent flower damage due to FAW was recorded. The damage on the foliage was not observed on the cotton crop. The intensity of damage was severe on bolls compared to flowers. The infested bolls started rotting due to larval excreta, rain water, and secondary pathogenic microorganisms through large holes bored by larvae. The nature of damage by FAW are similar to those of American bollworm (*Helicoverpa armigera*).
The crop duration of maize is short ie. 100 to 110 days while the crop duration of the cotton is long upto 180 days. After harvesting of the maize crop, FAW may shift on the neighbouring cotton crop

which presents in fruiting stage at 100 DAS may feed on the flowers, and developing bolls of cotton. The FAW infestation was also recorded on other crops like maize, sorghum, bajara and sugarcane in the vicinity of infested cotton crop. More or less, all these crops are grown in the premises of the visited village Susare, indicating the ample diversity of food crops for FAW. The FAW is a polyphagous pest, mostly prefers the hosts of graminae family like maize, jowar, bajra, Sugarcane etc but in the absence of preferred host plant and when the pest pressure would be high, it feeds on fruiting bodies of cotton crop.

The larval and adult samples of FAW were sent to IARI, New Delhi for Confirmation. Report received about the confirmation of FAW. This is the first report of FAW on Bt cotton in India, which was confirmed from the, All India Coordinated Research Project, CICR, Coimbatore (TN).

3.26

Constraints and Suggestions of the cotton growers for effective Management Pink Bollworm *Pectinophora gossypiella* Saund. in Maharashtra

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Pink bollworm is a major insect pest of Bt cotton in Maharashtra. Integrated Pest Management (IPM) technology is one of the important tool in pest management. A study was conducted in Aurangabad and Nanded districts of Marathwada region of Maharashtra. A sample of 240 cotton growers were selected for present study which categorized into 120 IPM-cotton growers and 120 non- IPM cotton growers. The constraints faced by IPM-cotton growers were studied and it was found that, unavailability of quality pheromone traps and scientific light traps for the control of pink bollworm at agro service centre proper time. (98.33%), unavailability of bioagents such as *Trichogramma*, chrysopa eggs etc. at proper time. (96.67%), unavailability of quality biopesticides like neem ark, *Beauveria, Verticillium* (95.83%), lack of demonstration and training on installation of pheromone traps, light trap, yellow and blue sticky traps, use of bioagents for IPM. (92.50%) was ranked IV; lack of proper multidisciplinary linkage among SAUs, ICAR, Agri. Dept. Producers and users (90.00%) as the major constraints. In case of suggestions the IPM cotton growers expressed their suggestions to overcome constraints in Integrated Management of pink bollworm were quality

pheromone traps and scientific light traps should be provided by government (95.00 per cent), Timely supply of trichocards, chrysopa eggs by biocontrol laboratories of state Agri. department and SAU's (93.33%), Good quality biopesticides like neem ark, *Beauveria, Verticillium* should made available at cheaper rate (91.67%), lack of demonstration and training on installation of pheromone traps, light trap, yellow and blue sticky traps, use of bioagents for IPM should be organized by State dept. of Agriculture, SAUs. (89.17%), Trainings should be organized on scientific installation of pheromone traps, light traps by state dept of Agri., SAU's and KVK. (87.50%).

3.27

Manipulations of source sink relationships under high density plating system (HDPS) for enhancing cotton productivity

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An experiment was conducted during *Kharif* 2017 at Punjab Agricultural University, Regional Research Station, Bathinda to manipulate source sink relationships in cotton under high density plating system (HDPS) with application mepiquat chloride (MC). The Non-Bt compact genotype F2383 recommended for HDPS was grown at spacing of 67.5×15 cm. The experiment consisting three nitrogen levels i.e 100% recommended dose of nitrogen (RDN), 125% RDN and 150% RDN and three levels of plant growth retardants i.e Control, MC @ 20 g a.i./ha at 60 DAS and MC @ 20 g a.i./ha each at 60 and 75 DAS. In case of nitrogen levels, sympods per plant, bolls per plant and seed cotton yield were increased significantly with 25% increase in recommended dose of nitrogen, while further increase in nitrogen level from 125 to 150 % RDN did not significant results. Similarly, NUE and monetary returns were also increased significantly with increase in nitrogen level from 100 to 125% RDN. Among the growth retardants, application of MC @ 20 g a.i./ha once and twice reduced plant height, increased sympods and boll per plant significantly which led to significantly higher seed cotton yield production as compared to control. NUE and monetary returns were also significantly higher under MC treatments as compared to control. It is concluded that application of MC @ 20-40 g a.i./ha manipulate source sink relationship which resulted in higher productivity and profitability.

AUTHOR INDEX