3.9: Nutrient Management

(i) Bio enriched compost effects on growth and yield

Bio-enriched compost from cotton plant residues was evaluated for its performance on growth and yield of cotton in a field experiment. Averaged over three years (2012-13, 2013-14, and 2014-15), the present INM practice (PINM), treatment (60:30:30 + 5T FYM) was found to yield significantly higher SCY followed by recommended NPK (90:45:45), and modified INM (60:30:30 + 5T cotton compost). The modified INM (MINM) treatment (Fig. 3.9.1) along with seed treatment with microbial consortia was similar to the RDF without microbial seed treatment. Treating cotton seeds with microbial consortia showed significant yield advantage as compared to the corresponding treatments without microbial seed treatment (Fig. 3.9.1). Boll weight was not affected by any treatment. This study shows that cotton compost can be used as a source of organic manure in the integrated nutrient management for cotton.

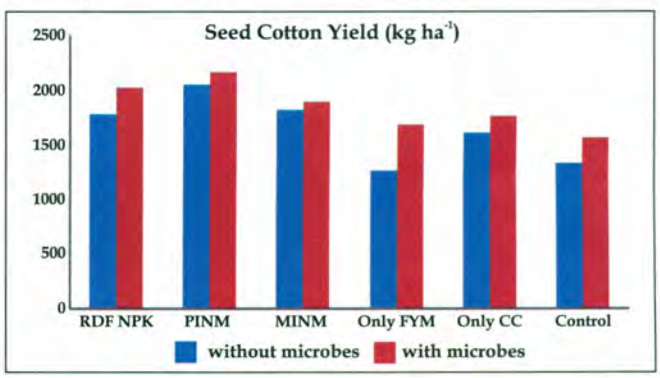

Fig. 3.9.1: Effect of cotton stalk compost on seed cotton yield

(ii) Evaluation of Potassium Silicate formulations on cotton production and protection

The effects of Potassium Silicate formulations

(Agrisil or Potassium Silicate powder) on cotton yield, quality, pest and disease management were evaluated in field under natural and artificial conditions. Under artificial conditions, BLB suspension @ 2 x 10^{10} spores/ml was sprayed at 80 DAS. Suraj (un-treated) seeds were used as test material at a spacing of 45 x 15 cm.

Based on the two year field study (2013-14 and 2014-15), it was found that there was no yield advantage with application of Potassium silicate formulations (Agrisil or Potassium silicate powder) either as seed treatment, soil application or foliar spray. Further, no effect of potassium silicate was observed on disease (20, 40, and 60 DAS) and sucking pests (aphids, whitefly, Jassid, Thrips) incidence. Potassium silicate powder @ 2000 ppm as seed treatment recorded significantly lesser aphid population i.e 1.58 aphids/3 leaves/plant compared to other treatments at 60 DAS.

(iii) Evaluation of nano nutrient formulations for cotton production

Among the commercially available nanofertilizers *viz.*, Richfield, Agriklik, Nualgi and Nanomol were evaluated at Coimbatore. Cotton growth and yield was highest with foliar application of Nanomol followed by Nualgi. Unlike combined nutrient nanofertilizers, single micronutrient nanofertilizer *viz.*, Nanobor was the best for increasing the cotton yield.

In another trial, application of nano iron oxide recorded more opened bolls, increased boll weight and higher seed cotton yield as compared to magnetite nanoparticles, normal iron oxide and iron sulphate fertilizers. Seed cotton yield was increased by 14% over control, 10% over normal iron oxide, 7.5% over iron sulphate and 6.17% over magnetic iron nanoparticles due to the foliar application of nano iron oxide. 0.5 g/lit of nano iron oxide increased the seed cotton yield which is followed by 1.0 g/lit and 1.5 g/lit of nano iron oxide. Similarly, 60 ppm of nano zinc oxide (50 nm) was much effective in increasing the seed cotton yield as compared to other nano zinc oxide nutrients. The efficacy of nanomagnesium oxide was on par with normal magnesium sulphate. Among the copper sources of nutrients, application of copper oxide nanofertilizers (40 nm) significantly increased the cotton yield as compared to control.

3.10 : High Density Planting Systems (HDPS) for Maximizing Productivity

On a Vertisol under rainfed conditions at Nagpur, 12 genotypes were evaluated across 3 spacings (45x10, 60x10 and 60x30 cm). The effects of spacing, genotypes and spacing x genotypes interaction effects were significant for seed cotton yield, bursted bolls (per sqm) and boll weight. Across genotypes, yield at 45x10 cm and 60x10 cm were 28.4 and 22.6% higher than that at 60x30 cm (1534 kg/ha). Relative yield of genotypes at different spacings (taking yield at 60x30 cm spacing as 100) is provided in Fig 3.10.1. Top five high yielding genotypes under each spacing were:

45 x 10 cm: H-1098i, DSC-99, G-Cot 16, PKV-081, Kandya

60 x 10 cm: Kandya, H-1098i, CSH-3178, BS-279, NH-615

60 x 30 cm: NDLH-1938, H-1098i, Suraj, PKV-081, G-Cot 16

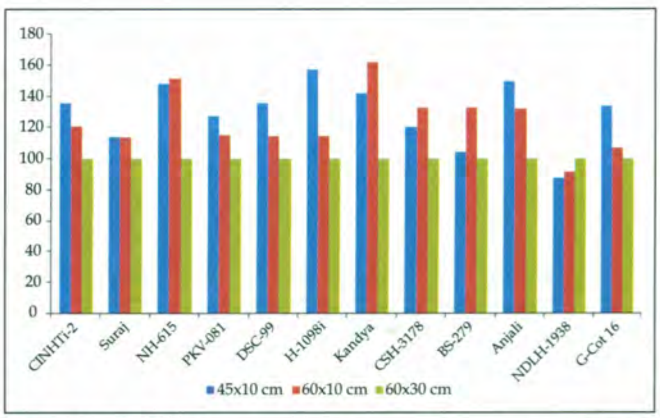

Fig. 3.10.1: Relative seed cotton yield (taking yield at the recommended 60 x 30 cm as 100) of 12 cotton genotypes at 45 x 10 cm, 60 x 10 cm spacing

Averaged over the spacings (45 x 10, 60 x 10 and 60 x 30 cm), CINHTi2 (16.4 PDI) and H 1098i (21.1 PDI) recorded lowest bacterial blight incidence, Anjali (10.4 PDI) and H 1098i (10.9 PDI) recorded lowest *Myrothecium* leaf spot incidence and NDLH 1938 (11.3PDI) and NH 615 (12.0 PDI) recorded lowest *Alternaria* leaf spot incidence respectively.

Among the genotypes evaluated under HDPS, NH 615 had the lowest incidence of aphids (0.99/3 leaves/plant), CINHTi2 had the lowest incidence of whiteflies (0.8/3 leaves/plant) and both NH-615 (2.32/3 leaves/plant) and G.Cot-16 (2.46 nymphs/3 leaves/plant) had very low incidence of jassids. Row spacing did not differentially influence the square damage due to bollworms.

Among eighty eight new entries evaluated at 60x10 cm spacing, entries -SPS-9, SPS 27-1, SPS 7-1 and AR-27 (a germplasm line) were found superior to check (NH-615) for yield.

Foliar sprays of KNO_3 2 % twice at 14 days interval, 2 sprays of CICR- Nutrient consortia at 14 days interval, 2 sprays of Mepiquat chloride @ 25 g ai/ha and spray of 2% each of urea followed by DAP at 14 days interval were effective in increasing boll weight under HDPS.

In a year of early season drought, post emergence (PE) application of Propquizafop + Pyrithiobac 1.8 ml L^{-1} at 25 DAS, followed by Glyphosate 4 ml L^{-1} 60 DAS PE produced high yield and had high weed control index. It gave highest net returns and proved to be a good weed control option under HDPS.

Under irrigated conditions on sandy loams of north zone, on the basis of mean performance for three years, CSH-3158, CSH-3132, CSH-3178, RS 2525 selection and Bhiani 251 were found promising for HDPS (67.5 x 10 cm). Yield of different genotypes at 67.5 x 10 cm along with that

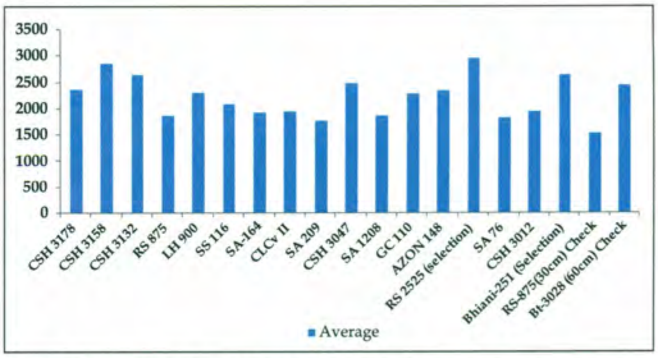

Fig. 3.10.2: Seed cotton yield (kg/ha) of semi-compact genotypes at 67.5x10 cm spacing along with checks Rs. 275 at 67.5x30 cm and Ankur 3028 BGII at 67.5x60 cm spacing.

of checks (RS 875 at 67.5 x 30 cm and Ankur 3028 BGII 67.5 x 60 cm) are provided in Fig 3.10.2.

Under winter irrigated conditions of Coimbatore, seed cotton yield of 3313 and 2804 kg/ha by Anjali and 3164 and 2992 kg/ha by Suraj were harvested respectively with irrigated and protective irrigated condition under HDPS. However, compared to Anjali, the variety Suraj under HDPS gave significantly higher net return under irrigated and protective irrigated condition. Under HDPS, the response to Mepiquat chloride application on yield was not significant in both the varieties.

Amongst different planters evaluated at Coimbatore, inclined plate planter was found to be the most efficient and cost effective.

At Coimbatore, under irrigated conditions with seven compact genotypes having super okra leaf and three check varieties - Suraj, Anjali and Supriya were evaluated at closer spacing of 30 cm x 15 cm. The super okra cultures showed high level of field tolerance to sucking pests and no insecticides were

Super okra leaf culture evaluation in station trial at Coimbatore

sprayed for their control. The highest seed cotton yield of 3492 kg/ha was recorded in Surabhi x M5Z2 4-2 Bk as against 3137 kg/ha recorded in the best check variety Suraj. Fibre quality data indicated the superiority of Surabhi x M5Z2 4-2 Bk for bundle strength recording 24.6 g/tex as compared to 23.9 g/tex in variety Suraj.

Twelve varieties of *G. arboreum* suitable for surgical cotton were evaluated on a Vertisol at Nagpur. CNA-375 was the top yielder followed by CNA-418, MDLABB and Phule Dhanwantary. Phule Dhanwantary was the most compact and accumulated the least dry matter and had the highest harvest Index. It was also amenable to planting at 30 cm row spacing.

Among the *G. arboreums* evaluated for surgical cotton purpose, CNA 2014-2, CNA 2014 -3, CNA 2014-4, CNA 2014-7 and CNA 2014-8 showed good absorbency characteristics and met the IP standard.

3.11: Weed management

(i) Evaluation of herbicides in cotton

Among the different concentrations of glyphosate tested on medium black soils of Nagpur on cotton (Var Suraj) under HDPS (60 x 10 cm spacing), 5 ml/l and 7.5 ml/l dose was effective in killing both the broad leaved and grassy weeds. With enhancers, combination of even a very low concentration of glyphosate (1ml/l) and 100 mM ammonium sulphate was effective in killing the weeds. Glyphosate activity was also increased by other enhancers such as 100 mM KH_2PO_4, 2% urea and 5% neem oil, however at a slower rate compared to ammonium sulphate.

Among the 48 different combinations of doses of glyphosate, Targa super (Quizalofop ethyl), Agil (Propaquizafop) and Hitweed (Pyrithiobac-sodium), combination of glyphosate 2.5 ml/l and 2.5 ml/l of Targa Super was found effective in killing both broad leaved and grassy weeds.

In order to reduce the cost incurred in weed management of cotton, cheaper herbicides were evaluated on black soils of Nagpur. Chlorimuron ethyl was evaluated (as Post- emergence application) in HDPS and BGII -hybrid cotton and it was found effective in killing most of the broad leaved weeds and some grassy weeds. The top application of Cyhalofop butyl, a soybean herbicide and Azimsulfuron a rice herbicide were tolerated by cotton and were effective in controlling grasses besides some broad leafed weeds. After standardizing their doses and stage of application, they can be introduced under herbicide rotation for effective and economical weed management. Bys pyribac Na, a rice herbicide and soybean herbicide Imzethapyr + Imzomax mixture cannot be tolerated by cotton since the cotton plants become stunted and failed to recover.

(ii) Allelopathy as an alternate weed management strategy in cotton

One of the major issues is timely weed control in rainfed cotton grown on Vertisols because the soils become sticky and wet after rains and are very hard when dry conditions prevail. As a result, the window for effective weed control becomes very narrow. A cover crop that has allelopathic effects to weeds is a possible solution for integration with mechanical methods. Field studies were conducted at Nagpur and Coimbatore to evaluate the efficacy of cover crops known to possess allelopathic effects.

At Nagpur, sunnhemp, bajra, sesame, sorghum and marigold had significantly reduced the weed dry matter accumulation. Total weed control was provided by newspaper mulch and polythene mulch. Aromatic cover crops such as fennel, fenugreek, caraway, coriander, bitter cumin were not as effective due to low biomass produced by these crops.

At Coimbatore, thorn-less mimosa, forage cowpea, coriander, fenugreek, sesbania and sunnhemp provided effective weed control. Moreover, the highest (2792 kg/ha) seed cotton yield was obtained with forage cowpea and it was on par with thorn less mimosa (2720 kg/ha), sesbania (2689 kg/ha), sunnhemp (2651 kg/ha), coriander (2598 kg/ha) and fenugreek (2592 kg/ha). Creepers (bitter gourd, ash gourd, and cucumber), horse gram and ajwain were found ineffective for their weed control efficacy.

Based on the consistent performance of sunnhemp over three seasons at two locations, it can be explored as a technology for weed control. Being a legume sunnhemp also fixes N in the system.

3.12 : Soil Biology and Biochemistry

The uninoculated control with structured water yielded 3135 kg seed cotton/ha as compared to 2695 kg/ha under borewell irrigated water. Among the bio-inoculants, foliar spraying of PPFM @ 1 % (twice during flowering to boll development) along with seed treatment + soil treatment of azophosmet recorded significantly higher seed cotton yield of 3404 kg/ha under structured water and 3009 kg/ha under bore well water. The uninoculated control recorded significant reduction in seed cotton yield than combined application of seed treatment + soil application and foliar PPFM and was on par with either seed treatment and seed+soil application of azophosmet. The seed cotton yield was enhanced significantly due to structured water (3297 kg/ha as against 2849 kg with bore well) irrigation. The roots of structured water irrigated cotton had higher CEC (20.5 meq/g) than bore well irrigated water (18.12 meq/g). The chlorophyll content was 4.4 mg/g of fresh leaf at 60 DAS in structured water cotton as against 3.3 mg/g recorded with bore well water. The plants were also taller (120.5 cm) as against 116.2 cm under bore well irrigation at harvest.

3.13 : Abiotic Stress Management

(i) Drought Phenotyping

Field phenotyping of 350 cotton germplasm accessions was done for drought tolerance during rain free hot dry summer days (April-May) with high air temperatures between 38 - 43 °C. Eighty seven cotton germplasm accessions were identified as drought tolerant based on percent relative water content, leaf water potential and epicuticular wax content. Among the 87 accessions, Nagpur-9, SGNR-27, F-1226 and DTS-108-09 performed well under drought stress conditions.

G. hirsutum **germplasm accessions showing few plants with drooping leaves due to lower mid-day water potential and few plants with upright leaves due to high mid-day leaf water potential during hot summer**

(ii) Role of Leaf Phytochemicals in cotton leaf reddening

Reddening in RCH 2Bt plants of the experimental plots at CICR Nagpur was observed during the first week of November. The plants faced declining night temperatures (16 -17^{0}C) during the preceding week and experienced a larger difference between night and day temperature ranging from 13- 20^{0}C during the week. Severity of reddening increased when the night temperature declined followed by longer bright sunshine hours during the day from third week of November. Red pigmentation in majority of plants including monochrotophos treated plots was observed during third week of December when night temperatures fell below 10^0 C. To ascertain the protective role of pigments during the process of leaf reddening, chlorophyll stability index was estimated in red and green foliage of RCH 2Bt. Chorophyll stability index was higher in red leaves of RCH 2Bt (70.5 %) than green leaves (64.5%). Based on visual screening, monochrotophos (3 ml/l), kinetin 20 ppm and CICR Nutrient Consortia treated plants showed a delay in the onset of reddening as compared to the other treatments. However, monochrotophos (3 ml/l) sprayed plants remained healthy with relatively higher percentage of green foliage followed by CICR Nutrient Consortia treated plants. Percentage of red plants was lower in monochrotophos treated plants.

(iii) Climate change- adaptation and mitigation strategies in cotton

Plants grown under elevated CO_2 atmosphere gave significantly higher yields of 69.8 g/plant compared to 55.4 g/plant under ambient conditions. Pruned crop gave marginally higher yield in both elevated CO_2 and ambient atmosphere. For instance, under elevated CO_2 atmosphere pruned crop gave 75.5 g /plant yield compared to 64.2/plant in seeded crop. Similarly, under ambient atmosphere, pruned crop recorded yield of 61.1 g/plant compared to 49.8 g / plant in seeded crop. Among the hybrids, MRC 6918 recorded the highest yield of 90.1 g/plant irrespective of growing conditions. Total dry matter production was significantly higher in plants grown under elevated CO_2 recording 234.1 g/plant compared to 197.5 g/plant in ambient grown plants. Pruned crop gave higher biomass production in both elevated and ambient condition. Pruned crop on an average produced 250 g/plant compared to normal seeded crop (182 g/plant) irrespective of the hybrids tried. Among the hybrids, MRC 6918 gave highest dry matter of 321.6 g/plant. Plants grown under elevated CO_2 recorded a harvest index of 30.3% compared to 28.5% in plants grown under ambient conditions.

Bunny Bt cotton was raised in open top chamber under elevated CO_2 atmosphere (650 ± 50 ppm) throughout the cropping season. Temperature of 1, 2 and 3°C above ambient was maintained without affecting the Photosynthetic Active Radiation value (PAR). Boll number increased significantly with 1°C rise in temperature above ambient (30 bolls/plant) and decreased to 17 bolls/plant with further increase in temperature of 3°C above ambient atmosphere. Similar trend was observed for boll weight i.e reduction in boll weight with increase in temperature above 2°C from ambient. This reflected on final yield of the crop. With increase in 1°C above ambient, plants produced 143 g/plant seed cotton while further increase of 2 and 3°C reduced the yield to 101 and 81 g/plant respectively. Similarly, the total dry matter production increased marginally with 1°C rise above ambient to 455 g/plant and reduced with further increase in temperature to 408 and 370 g/plant under 2 and 3°C respectively. Harvest Index was maximum in plants grown under temperature 1°C above ambient. However, a drastic reduction was recorded in plants grown under 3°C above ambient. The study revealed that the morphological and productivity attributes were favorable in plant grown at ambient or 1°C above ambient under elevated CO_2 atmosphere of 650 ppm. Further increase in temperature above 1 °C had a deleterious effect on plant growth and development.

On large plots of 500 m^2 each, soil moisture conservation strategies was demonstrated on CSH 3178 genotype of cotton planted in high density planting system (HDPS) at 60 x 10 cm spacing at Nagpur on deep black soils under rainfed conditions. The yield realized in control (without conservation was 1198 kg/ha and the yield gain (over control) was 120 kg/ha with Pusa Hydrogel (single dose)@ 3.25 kg/ha, 300 kg/ha with Ridges & Furrow, 299 kg/ha with bio mulch and 350 kg/ha with Pusa Hydrogel (double dose) @ 6.5 kg/ha.

3.14 : Extra Long Staple (ELS) Cotton in Non-Conventional Regions

Extra long staple cotton production in the southern states declined. Consequently, large amount of ELS cotton is imported to meet textiles industries demand. The kinetic thermal window of cotton crop is 23.5 to 32.0°C. Hence to assess the performance of ELS cotton in central India under slightly harsher climatic variables, the ELS cotton variety SUVIN was sown at weekly intervals (18 July, 25 July, 1 Aug and 8 August). The total rainfall received from first date of sowing (18.7.2014) to first picking (5.2.2014) was 743 mm. The monsoon ceased on 18 September. Thereafter continuous dry spell caused significant moisture stress in crop root zone. During this time, the crop was at boll formation stage and it was highly essential to save the crop from severe moisture stress for which one protective irrigation was given on 28/29 October, 2014.

Seed cotton yield, yield contributing parameters and water use (ET crop) were affected due to differential dates of sowing. In case of early sown crop (18 July 2014), the seed cotton yield on an average was 1214 kg/ha and comparable to crop sown on 25 July. However, in case of subsequent sown crop (1 August and 8 August), a reduction in seed cotton yield was of the magnitude of 17% and 33% respectively as compared to the crop sown on the first date. Application of Pusa Hydrogel (@ 5 kg/ha) had no additional benefit as compared to normal crop. Water use efficiency, which was calculated based on ET crop was also affected and delayed sown crop had very low water use efficiency as the crop was severely affected due to non availability of soil moisture in crop root zone. Total number of bolls in all sowing dates ranged from 42 to 59 bolls m^{-2}. The effect of sowing dates on boll number was significant with a great reduction under delayed sown crop. The boll weight was not affected due to delayed sowing and it was in the range of 2.99 to 3.36 g.

To assess the performance of 27 germplasm lines of *G. barbadense* with Suvin as check, a field experiment was conducted during *kharif* 2014 in a non-replicated trial. The lines were sown on 16 and 17 July 2014 with a spacing of 90 x 45 cm. On an average, seed cotton yield per plant was 39.6 g with maximum of 63. 2 g in case of ICB 81 and minimum of 19.4 g in case of NDGB 2. In case of standard check i.e. Suvin, the seed cotton yield per plant was 58. 4 g. The highest seed cotton yield recorded in four germplasm lines *viz*., NDGB 86, ICB 28, NDGB 55 and NDGB 9. The first boll opening was recorded between 4 and 11 December in all germplam lines except in case of Suvin, ICB 28, ICB 81, ICB 174 and USAGB 309. Boll opening in the germplasm lines was delayed by 21-26 days.

Fibre quality parameters : The variety Suvin has performed well with respect to staple length (34.16 mm), however the fibre strength and fineness and other relevant fibre qualities were comparable with other germplasm lines. Out of 27 germplasm lines, only seven lines NDGB1, NDGB20, NDGB 26, NDGB 35, ICB-81, ICB-174, EC 22 expressed staple length above 32 mm (32.19 mm to 34.0 mm) These lines also have fibre strength above 26 g/tex.

3.15 : Physiological Manipulation of Extended Cotton Crop

Three BG - II hybrids namely Bunny, RCH -530, and RCH- 20 responded favourably to pruning. Irrespective of the Bt cotton, 116.8 g/plant yield was recorded in normal seeded crop compared to 84.0 g/plant in pruned crop. Among the hybrids, highest yield was recorded in Bunny followed by RCH 530. Total dry matter production was significantly higher in seeded crop registering 408.0 g/plant compared to 317 g/plant in pruned crop irrespective of the hybrids. Bunny and RCH - 530 gave similar value of 390 g/plant. Soon after harvest in the month of July, the normal seeded crop was again subjected to pruning in the month of August 2014 as a winter crop. Adjacent to the pruned plot normal seeded crop was raised for comparison.

Irrespective of the hybrid, significant variation was not discernible between pruned and normal crop. Bunny and RCH - 530 yielded on par with 150.9 and 169.9 g/plant yield respectively, compared to 123.2 g/plant in RCH - 20. Plant growth in terms of total dry matter was almost 40-50% higher in winter than summer crop. Mean dry matter produced to the tune of 580.4 g/plant in pruned crop compared to 417.6 g/plant in normal seeded crop. Maximum dry matter production was recorded for RCH -530 followed by Bunny and RCH -20.

Cry1Ac toxin in leaves of all the Bt BG II version recorded more toxin than the first cycle of fruiting. Almost a similar level of toxin was maintained in the three hybrids studied (2.25 to 2.37 µg/g). Pruned crop almost had double the quantity of toxin (2.55-3.9 µg/g) than the normal seeded crop; (0.891-1.350 µg/g). Leaves had higher level of Cry2Ab toxin (460 µg/g) compared to squares in (406 µg/g) in the initial crop and also the quantity of toxin in the second crop (pruned crop) decreased. However, regardless of the fruiting cycle (normal and pruned crop) Cry1Ab toxin were at same level. Much variation could not be observed between leaves and squares in Cry1Ab toxin content.

3.16 : Mechanization of Cotton Production

The self-propelled cotton harvester fabricated and tested in 2013 was subjected to several modifications and field trials in order to obtain lesser trash content in harvested cotton. The grid concave inside the threshing unit was replaced with a larger size opening grid from 23x9 mm to 40x20 mm. The earlier grid size was suitable for small grains and it was observed that bigger trash like burs, sticks etc. were unable to pass through the openings, with the result that trash was not getting discharged through the grain outlet (outlet below the concave grid unit). Entire trash after getting separated from seed cotton in the grid concave was being discharged from the threshing unit into the pre-cleaner, where depending on the capacity and nature of pre-cleaner the trash was being separated from seed cotton and both discharged through separate outlets. With larger openings than above, it was observed more seed cotton mixed with trash got discharged through opening below the grid. With 40x20 mm grid size a trade-off between quantities of trashy cotton and cleaner seed cotton could be achieved. In field trials with RCH-2 BG-II hybrid about 80% harvested seed cotton came off relatively cleaner (25% trash) from the threshing unit and into the pre-cleaner while 20% trashy cotton (40% trash) got discharged from the opening below the grid concave unit.

Original Grid Concave

Modified Grid Concave

Clean stripped plants

Improved Reel

Combs with varying teeth spacing were fabricated to take care of different cotton genotypes having varying girth of lower stem and varying angles of branches. The mean stem girth of plants of RCH-2 was 11.3 mm and that of Suraj var. was 9.3 mm. Also, the height of plants dictated the efficiency of harvesting. Stripper harvester was found to give high harvesting efficiency of 95% when average plant height was below 75 cm and height of lower most boll above 10 cm. This was because stripper combs if lowered below this height resulted in digging in.

The gathering reel was found lacking in strength and unable to push the plants into the auger. A new reel was fabricated with strips of flat welded to a central shaft driven by a pulley. This improved reel did not jam and pushed in the stripped bolls positively into the auger.

Of the total trash in harvested cotton, the burs and sticks alone constituted 70-80%. Therefore, it is necessary to incorporate an extensive field/pre-cleaner in the machine itself. Power and space constraints exist in the present harvester to meet a pre-cleaner.

3.17 : Socio Economic Dimensions of Cotton Farming

e-Kapas for technology transfer

'e Kapas' refers to use of electronic technologies especially information and communication technologies (ICTs) for delivering location specific, time sensitive and important alerts based on cotton technologies to farmers, extension workers and other development workers engaged in cotton system. Need based advisories in regional and local language is provided on a regular basis after registration of cotton growers with their mobile number, collecting information on Frequently

Asked Questions (FAQs). Development of content in local languages, develop popular dissemination material on cotton production/protection technologies, weather, market information. Registration of interested farmers as beneficiary of e-Kapas network was made with their names, mobile numbers, villages, tehsil and districts for getting voice messages & advisories free of cost from CICR and participating centres. The farmers were also asked to register directly with short code services 123eworld.com (Mobi Tech Media) system.

During 2014-15, 11766 farmers were registered from CICR Nagpur. Similarly, 986 cotton growers from major cotton growing districts of Tamil Nadu *viz.*, Perambalur, Madurai, Virudhunagar, Salem, Vellore, Erode, Ariyalur, Trichy, Theni, Dharmapuri and Coimbatore were identified and registered. In addition, 3603 farmers was registered at Sirsa (Haryana). The details of the 37432 registered cotton growers so far were developed into a database called e-Kapas farmers' database.

In all, 27 FAQs in cotton were collected through Focus Group Discussions from cotton growers at Nagpur, 29 at Coimbatore and 18 FAQs were compiled at Sirsa.

During the crop season 2014-15, a total of 23.53 lakhs Voice SMS were sent on registered farmers mobile, out of which 16.79 lakhs were attempted successful and delivery percentage was 71%. Among the CICR, voice SMS of 10.09 lakhs (6.83 lakhs CICR Nagpur, 1.87 lakhs CICR RS Sirsa & 1.39 lakhs CICR RS Coimbatore) were sent with delivery percentage of 72%.

The coverage area when the voice message is sent, the system was adopted and the calls were repeated a couple of times to ensure that the farmer does not miss the message.

Feed back

Feedback revealed that voice based mobile services are useful in adoption of practices and farmers like to have voice messages at regular basis during season. The following feedback were recorded with respect to voice message system.

- A better source of timely, relevant and quick information
- Need based and location specific information
- Save time, money and easy to understand available information
- The service is useful to the people who cannot use internet or are not comfortable with text message
- Service is of a great use to illiterate farmers
- Source for strong linkage with research station
- Most farmers preferred mobile service through SMS too
- Farmers like to have toll free call back facility to contact the officers and scientist

Impact of Bt cotton in Maharashtra

This study was conducted to evaluate the impact of Bt cotton in Maharashtra. Data was collected from 2700 cotton farmers belonging to 18 major cotton growing districts of Maharashtra *viz.*, Ahmednagar, Akola, Aurangabad, Amaravati, Beed, Buldhana, Chandrapur, Dhule, Hingoli, Jalgoan, Jalna, Nagpur, Nanded, Nandurbar, Parbahani, Wardha, Washim and Yavatmal. During 2012-14, data collection and analysis for twelve districts was completed. The analyzed results for sample districts indicated that, though Bt cotton was introduced in 2002, most of the producers adopted Bt cotton during 2005-08 and by the end of 2011 almost 90 percent of respondents adopted it. Currently all the respondents are growing Bt cotton. Significant changes took place after introduction of Bt cotton and the important ones are listed in Table 3.17.1.

Nearly 89% respondents reported that sucking pest problem increased year after year. However, they felt that availability of pesticides was not a problem. As per the respondents there are more than 300 Bt hybrids in the market. They mainly depend on the advice of seed dealers/private companies for hybrid selection. Most of the respondents (64%) opined that selected hybrids were not giving expected yield which indicates that they are unable to make good decision regarding the selection of hybrids. Forty per cent of the respondents said that they were unable to get their preferred hybrid at MRP rate and they had to pay more than the MRP to get it. High yield, big boll size and quality of fibre are the three major traits preferred by the respondents. One-third of respondents were not using non Bt seeds as refugia, 55% of respondents used non Bt seeds as border crop and those who got red gram seed (10% of respondents) as refugia were using it an intercrop. Opinion survey revealed that Bt cotton was not responsible for suicides of cotton farmers (99% of respondents.). Almost all the respondents perceived that there were no incidence of death of animals due to Bt cotton and there were no health hazards due to Bt cotton cultivation. On an average, cotton farmers incurred a total working cost of Rs 19695/- acre and got a gross return of Rs 34428/- acre. Most of the respondents were not satisfied with the current yield and income levels. Hence measures to improve the yield should be taken and also government must ensure the remunerative price for their produce.

Table 3.17.1: Use of inputs before and after introduction of Bt cotton by sample respondents-District wise.

District	Seed rate (kg/acre)		No. of insecticidal sprays		Fertilizers (NPK) (kg/acre)		Respondents used weedicides (%)		Respondents used growth regulators (%)		Yield (q/acre)	
	Before-Bt	After-Bt	Before-Bt	After-Bt	Before-Bt	After-Bt	Before-Bt	After -Bt	Before -Bt	After -Bt	Before-Bt	After-Bt
Ahmednagar	2.8	0.5	7	4	93.4	174.5	1	25	1	8	5	9.4
Akola	2.4	0.8	8	3	66.8	102.7	1	8	1	32	3.6	8.5
Amravati	2.5	0.8	8	3	48.4	93.2	0	39	0	33	3.4	8.8
Aurangabad	3.5	0.6	6	5	90.3	156.7	0	21	0	10	4	8.2
Beed	2.8	0.8	8	4	60.2	110.6	0	10	1	23	4.5	8.0
Buldhana	2.5	0.8	7	4	72.6	143.6	3	35	1	24	4.4	9.8
Chandrapur	1.9	0.8	7	3	59.4	95.3	0	65	1	11	3.0	7.1
Dhule	2.6	0.6	5	3	50.9	92.0	0	28	0	21	4.4	8.2
Hingoli	2.0	0.9	6	4	89.5	174.4	1	55	0	12	3.8	10.7
Jalgaon	2.6	0.5	6	4	61.2	93.5	0	37	0	37	4.4	8.6
Jalna	2.3	0.5	6	4	85.2	135.0	0	27	0	10	4.8	8.2
Nagpur	2.2	0.7	8	4	48.9	95.9	0	39	0	33	4.8	8.1
Nanded	3.1	0.7	8	4	93.7	188.4	0	11	0	2	2.1	6.4
Nandurbar	1.8	0.8	7	4	54.5	93.0	0	29	0	27	4.1	9.7
Parbhani	3.2	0.5	9	5	99.0	130.3	0	19	0	37	2.8	7.1
Wardha	2.6	0.9	8	4	68.7	123.5	0	12	0	39	2.8	6.8
Washim	2.7	0.8	7	4	92.7	145.9	1	47	2	15	4.7	7.4
Yavatmal	2.0	0.8	8	4	66.8	156.5	0	39	0	28	1.5	6.2
All	**2.5**	**0.7**	**7**	**4**	**72.3**	**128.1**	**0.48**	**30**	**0.51**	**21**	**4**	**8.3**

Cotton price forecasting

The ARIMA model of Box-Jenkins analysis showed almost near normal values of actual to the forecasted prices for the cotton markets of Gujarat and Madhya Pradesh. Significant variations in the forecasted prices with that of actual prices were noticed in case of cotton markets at Maharashtra. Forecast accuracy was to the tune of 95% in case of Gujarat and 96% for Madhya Pradesh but slightly wide variation in case of Maharashtra with 88.4%. In case of North Zone, forecast accuracy was to the tune of 91% in case of Punjab, 89% in Haryana and 90% in case of Rajasthan.

Cotton Mechanisation - Tracing the Needs and Gaps for Sustainable Cotton farming in India

The objectives of this project were to compute the intensity of labour shift from cotton to other sectors; to trace the current mechanisation status and future needs among the different categories of cotton farmers and to suggest viable means for increased productivity in cotton.

Our country lags behind many other large producers of cotton in terms of mechanization. It is reported that the labor availability has dropped from 70% of the population in 1961 to 49% in 2010. Thus, it is expected that we will soon have to mechanize our cotton harvesting operations as it is facing labor shortage and rising farm wages.

Mechanisation gap is found in almost all the stages of the crop except during the land preparation stage. Therefore, top priority of mechanization needs to be given to the cotton farms during sowing, intercultivations mainly weeding and harvesting stages. Cotton harvesting has to be mechanized so as to counter act 50% of the cost of cultivation. It could be seen that human labour cost of weeding and harvesting operations account for 60% of the total labour cost followed by land preparation (16%), plant protection (9.6%), fertiliser application (8.1%) and sowing (4%). Partial budgeting technique was used to find the economic viability of mechanization under selective operations wherein the labour use is high with special reference to sowing, weeding and harvesting operations. The results showed an increased benefit of Rs. 8000 to Rs. 9000 per hectare in all these three operations.

Selective mechanization is the need of the hour. Farm mechanization zone is to be identified in both the rainfed and irrigated cotton farms in all the three cotton zones where labour is scarce. Care should be taken that mechanization should not destabilize the agricultural labour availability. Contract or Co-operative farming in cotton can be encouraged for effective and optimum utilization of the resources to achieve highest yield as targeted for 2020. Increasing irrigation facilities and adoption of scientific innovations and modern technologies like Bollgard II Roundup Ready Flex, mechanised farming and the High Density Planting (HDP) programme are some of the key focus areas which can provide the much needed fillip to increase the productivity level further.