## 3.10 : Integrated Crop Nutrition Management

### Nagpur

**Practical Approaches to Maximize the Cotton Production in Calcareous Soils**

Cotton production on calcareous soils is constrained by severe multiple nutrient deficiencies. Station field experiments were conducted with 10 different nutrient treatments to improve seed cotton yield of *G. hirsutum* cultivars PKV081 (60 x 30 cm spacing) and Ankur 3028 BGII (90 x 60 cm). Seed treatment with humic acid (0.02%), Azotobacter and phosphorus solubilizing bacteria increased percent germination and rate of nutrient absorption. Humic acid (0.02%) treated seed along with 125% recommended dose of fertilizers and micronutrient application (15 kg ha$^{-1}$ for hybrid and 12 kg ha$^{-1}$ for variety) produced more seed cotton yield than the foliar spray of chelated micro nutrients (0.5%) at 45 to 60 DAS.

**Cotton production on calcareous soil**

**Participatory technology & e-tools development for calcareous soils**

Participatory trials were conducted on calcareous soils in Budhala, Ladai-Linga, Khairi-Deshmukh, Lohagarh-Budhala of Kalmeshwar Tehsil in Nagpur district. Plots receiving the biofertilizer (*Azotobacter +Azospirillum* + PSB and *Trichoderma viride* treated seed) treatment along with 125% recommended dose of NPK + Mg, S, Fe, Mn, Zn and B produced 2.0 q ha$^{-1}$ more seed cotton yield over the 100% NPK. Seed treatment with humic acid and soil application of chelated micronutrients along with 125% NPK resulted in 2.8 q ha$^{-1}$ more seed cotton yield with favourable cost benefit ratio over the 100% RDF (N:P:K ::80:40:40 kg/ha). Results indicate that micronutrients need to be supplied in a chelated form in highly calcareous soils. Possible phytotonic effect provided by humic acid improved root proliferation in calcareous soils under ridges and furrows type of rain water conservation.

Among the BGII hybrids evaluated on calcareous soils in an on-farm trial, RCH-659 produced the highest seed cotton yield under rainfed condition with two supplemental irrigations (18.5 and 32 q ha$^{-1}$) followed by Ankur 3028 and Denim.

**Bio-efficacy trials of plant growth promoter based on waste human hair developed by MGIRI**

Commercially available plant growth promoters that are recommended for cotton are usually costly. Human hair is a waste product and is rich in amino acids. Waste hair was extracted and a mixture was developed by Mahatma Gandhi Institute for Rural Industrialization (MGIRI), Wardha. Field trials were conducted in collaboration with MGIRI to test the efficacy of the formulation from waste human hair and cow urine. The product was applied as a foliar spray at three different concentrations (6, 9 and 12 ml/l). The product was sprayed either two or three times fortnightly from 60 days after sowing (DAS). Compared to the NPK treatment and NPK + water spray, the human hair extract sprayed two times resulted in significantly higher seed cotton yield (Fig 3.10.1). There was no benefit when the number of spray was more than two. The plots that were sprayed three times had few bolls (35.3 bolls per plant with two sprays vs. 31.3 bolls per plant with three sprays). Preliminary results indicate that there is a scope of using the waste human hair as a plant growth promoter.

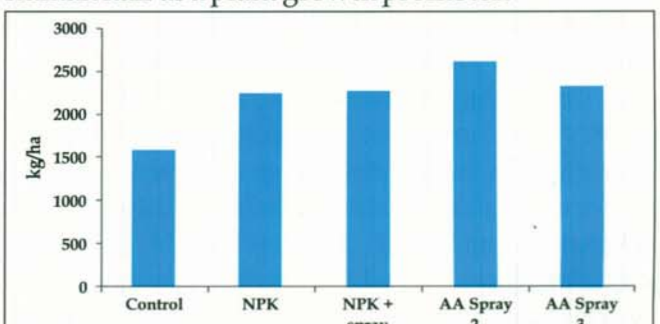


**Fig 3.10.1: Effect of spray of waste human hair on seed cotton yield**

### Coimbatore

**Evaluation of commercially available nanofertilizers on cotton growth and yield**

Field experiment was conducted to evaluate the effectiveness of foliar application of nanofertilizers like Nualgi and Nanomol with or without surfactant at different dosages. Results indicated that an application of higher dose of nanofertilizer (200%) like Nualgi increased physiological parameters of the plant like number of leaves, leaf area index, reducing sugar and total chlorophyll content. Even though, the physiological attributes were improved by high dose of nualgi nanofertilizer with surfactant, yield related parameters (number of opened bolls and seed cotton yield) did not increase by higher dosage of nanofertilizers like Nualgi and Nanomol. Normal recommended dose of both nanofertilizers i.e., 100% only increased the seed cotton yield without surfactant. But there was no significant difference among the treatments. This may be due to severe infestation of alternaria blight during the rainy period i.e., 110 DAS resulting in drop of foliage.

Another field experiment was conducted to study the interacting effect of the best performed four different types of metal oxide nanoparticles like zinc, iron, copper and magnesium with organic fertilizer i.e., seaweed liquid fertilizers. Experimental results indicated that an application of single and combined form of metal oxide nanoparticles increased the physiological parameters. However, these parameters were not improved by combined application of metal oxide nanoparticles along with seaweed liquid fertilizers. The possible reason that nutrient entry, uptake and translocation may be reduced due to complexation of smaller size nanoparticle with macro sized particles of seaweed liquid fertilizer and forms the bigger size particle or otherwise. Also, there may be a competition between nutrients in metal oxides and seaweed liquid fertilizers. Among those treatments studied, single micronutrient 100 ppm of ZnO (50 nm) nanoparticle increased the number of opened bolls as well as seed cotton yield which was followed by ZnO + CuO + MgO + FeO nanoparticle and then the same yield was recorded in combined form of ZnO + MgO + CuO treatment. These results need to be validated further.

## 3.11 : High Density Planting Systems (HDPS) for Maximizing Productivity

### Nagpur

**Evaluation of short, medium and long linted *G. arboreum* cotton under HDPS**

Of the 17 *G. arboreum* genotypes evaluated, eight were long linted with fibre length >27.5 mm. Seed cotton from all the genotypes was picked twice at 140 days and 165 days after sowing and the combined yield at 165 DAS is shown in Fig. 3.11.1.

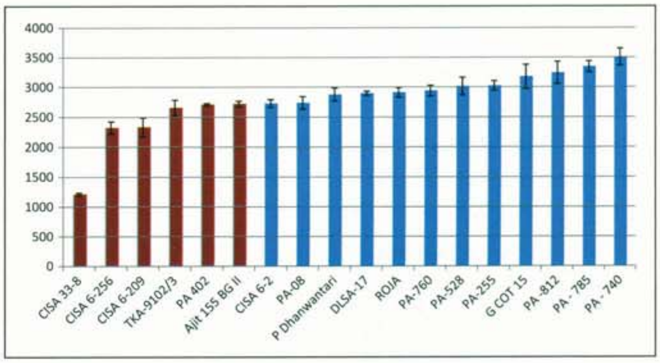


**Fig. 3.11.1: Mean seed cotton yield (kg/ha) at 165 days after sowing**

Differences among genotypes were statistically significant for the seed cotton yield. The genotypes that produced significantly higher seed cotton than Ajit 155 BGII Bt were PA 255, G. Cot 15, PA 812, PA 785 and PA 740. Thirteen genotypes *viz.* PA 255, PA 08, PA 528, PA 760, PA 402, Roja, CISA 6-2, Phule Dhanwantari, G. Cot 15, DLSa 17, PA 740, PA 812 and PA 785 gave significantly higher lint yield than Ajeet 155 BGII Bt. Based on proportionate yield at first pick, G Cot 15, DLSa 17 and Roja were relatively early. Genotypes G Cot 15, DLSa 17 and Roja were early with respect to days to the time taken for "first boll opening". Genotypes TKA-9102/3, DLSa 17, PA 740, PA 812 and PA 785 had fibres longer than that of Ajeet 155 BG II Bt.

**Evaluation of breeding material**

Two *G. hirsutum* entries *viz.* SPS 1-5-1 (3583 kg/ha) and SPSS 1-5-2 (3272kg/ha) were found significantly superior to check NH 615 in seed cotton yield.

These entries were compact and ideal for HDPS.

For surgical cotton production, three cultures of *G. arboreum viz.* CNA 2014- 4, CNA 2014 – 8 and CNA 2014 – 9 were selected on the basis of sulphate ash content, moisture absorbency, sinking time, water holding capacity and water soluble matter.

**Sirsa**

Replicated evaluation of 16 compact selections made from various genotypes with <1 monopodia indicated that compact selections of CSH 3088 (2428 kg/ha), AZON 148 (2486 kg/ha), CSH 3132 (2242 kg/ha) and SA 164 (2364 kg/ha) could out yield Bt check 6588 (1897 kg/ha) whereas other two checks used were F 2383 (1801 kg/ha) and F 1861(1897 kg/ha).

During 2016-17, in a station trial five improved cultures along with three checks were evaluated at recommended spacing. Culture CSH 1613 gave 2160 kg/ha against Bt check Bioseed 6588 BG-II (1950 kg/ha). Other cultures with higher yield were CSH 3622 and CSH 3047. From this trial cultures CSH 1613 and CSH 3047 were sponsored in AICCIP trials.

Fifteen *G. arboreum* compact cultures were evaluated in a replicated trial along with promising checks CICR 3, Phule Dhanwantari and HD 432. The culture G 166 (2400 kg/ha), AC 621 (2370 kg/ha) and 6040 (2380 kg/ha) were observed to be superior for yield. Another set of 15 *G. hirsutum* compact cultures were evaluated along with promising Bt check Bioseed 6588 and non-Bt check F 1861 and F 2383. The culture SA 1719 was observed to be significantly superior to varietal check F 1861.

## 3.12: Weed management

**Nagpur**

**Allelopathy - an alternative weed management strategy for cotton**

Weeding is a labour intensive operation and is one of the main factors for increasing cost of cultivation. Furthermore, the land is frequently tilled and hoed to obtain timely weed control which may not be possible under heavy rainfall situations. Herbicide usage has increased to obtain an effective weed control. Allelopathic cover crops are an alternative option to reduce the reliance of herbicides and further improve soil health because organic residue is recycled back into the soil. Twelve cover crops were evaluated at Nagpur. Among them, pearl millet and sorghum cover plots had significantly lower seed cotton yield than the weed free plot without a cover crop. All the remaining cover crops were similar with a higher yield in the sunnhemp cover crop plots. However, these differences were not significant. Total weed control was provided by olythene mulch and the plots also resulted in early harvest.

**Coimbatore**

At Coimbatore, forage cowpea, sesbania and sunnhemp had very low weed count and dry weight followed by thornless mimosa and *Desmanthes*. All the cover crop treatments provided effective weed control compared to the stale seed bed method without a cover crop. Seed cotton yield increased significantly with the sunnhemp and forage cover crop compared to the other cover crops and the control. Thornless mimosa, sesbania and *Desmanthes* had lower yield probably due to competition for space and resources with cotton.

**Studies to identify the low cost weed management solutions for HDPS cotton**

Major weed flora identified were grassy weeds *Echinocloa* sp. and *Cyperus rotundus*. Early post-emergence application of Glyphosate 4 and 6 ml $L^{-1}$ also controlled *Echinocloa* sp. and *Cyperus rotundus* effectively within 7-10 days after foliar application. Although glyphosate was very effective in controlling all weeds, it also suppressed the apical dominance of cotton with irrecoverable effect on crop growth. Hence, it can be used only as a late directed-application as confirmed in the previous years. *Echinocloa* sp. and *Cyperus rotundus* weeds were easily controlled by propaquizafop 1.8 ml $L^{-1}$ or chlorimuron 0.075 g $L^{-1}$, cyhalofop butyl 0.5 ml, pyrithiobac sodium 1.8 ml $L^{-1}$,fenoxoprop methyl 1.8 ml $L^{-1}$, quizalofop ethyl 4-5ml $L^{-1}$ or pyrazosulphuron ethyl 0.7 g $L^{-1}$.

## 3.13: Soil Biology and Biochemistry

**Nagpur**

Soil with available nitrogen from 17 legume intercrops in cotton of 1:1 ratio with 45 x 10 cm and 90 x 10 cm spacing rhizosphere samples were compared with legume monocrops (45 x 10 cm). Sunnhemp and sesbania were mulched on 45 DAS which recorded higher soil available N (0.045 g $kg^{-1}$) on 120 DAS than other grain legume (Fig. 3.13.1). Overall contribution of different legume varied with time during cropping season.

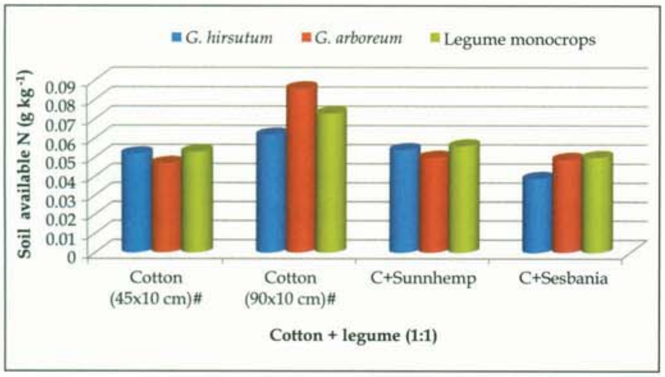


**Fig. 3.13.1: Effect of N fixing legumes intercrops on availability of Nitrogen in soil (g $kg^{-1}$) of cotton**

## 3.14 : Abiotic Stress Management

### Consortia Research Project (CRP) : Agro Biodiversity

#### Nagpur

Phenotyping of selected 2000 germplasm accessions of *G. hirsutum* was done for the last two consecutive years for drought tolerance. Among these accessions; IC-325280 was better performing whereas IC-357406 was moderate and 3944 had a poor performance with regard to drought tolerant traits.

**Field view of *G. hirsutum* germplasm accessions in response to heat and moisture deficit conditions**

### MAS/MAB for Waterlogging in Cotton

#### Nagpur

Screening of 242 *G. hirsutum* germplasm lines was carried out under water logging conditions. Forty five days old cotton plants were subjected to continuous water logging by maintaining a water level of 15 cm for 25 days. Among the short-listed germplasm lines from the previous year; 25 were screened for water logging tolerance. Lines identified for water logging tolerance and susceptibility were grouped based on presence and absence of lenticels and adventitious roots. These lines were also evaluated for leaf senescence characters and yield attributing characters. Sixteen lines were shortlisted for water logging tolerance and 62 for moderate tolerance.

**Response of germplasm lines of *G. hirsutum* to waterlogging**

### Exploiting the epigenetic transgenerational inheritance of stress responsive traits for imparting abiotic stress tolerance in cotton

**Coimbatore**

Suraj and LRA 5166 seeds were treated with different concentrations of five Epigenetic Regulating Chemicals (ERC) 5-Azacytidine - 10μM, 5- Azacytidine – 40 μM, Sulfamethazine- 10 μM, epigallocatechin gallate- 100 μM, Nicotinamide – 35 μM and sown in germination trays along with control to study the germination compatibility. Germination percentage was similar to the non-treated control in both the varieties and no malformations in seedlings were observed. Hence the chemicals used were compatible for seed germination. These plants treated with ERC will be screened for drought tolerance in the subsequent generation. Pot culture experiment was conducted with cotton varieties Suraj, LRA 5166, 891 and Nagpur 9 and drought stress was imposed at flowering stage for 5 days and re-watered. Generation is advanced and $F_1$ plants are being screened in the field for drought tolerance and stress memory.

**Correlation of leaf colour transmittance with soil/plant nutrient status**

Field experiment was conducted with 6 levels of N (0% RDN, 25% RDN, 50% RDN, 75%RDN, 100% RDN and 150% RDN) with variety Suraj with three replications. SPAD values of $4^{th}$ leaf from the top 5 plants/replication were recorded and correlated with N content estimated from the same leaves. Correlation coefficient (R) of 0.715 was obtained between SPAD values and N content of cotton leaves which is slightly lower than the correlation coefficient (R) of 0.795 between N content and greenness values obtained by the gadget "Nitrogen Guru" during 2015-16.

## 3.15 : Cropping Systems

### Nagpur

**Efficient nitrogen fixing legumes for cotton based cropping systems**

Nitrogen fixing legumes can restore soil fertility and reduce dependency on fertilizer-N. Seventeen N fixing legumes were evaluated as an intercrop in rainfed cotton at 1:1 row ratio with a spacing of 90 x 10 cm. Intercropping with *kharif* legumes improved soil nitrogen content at 120 DAS. *Rabi* legumes germinated well; however, their growth was poor in 150 DAS of cotton due to insufficient soil moisture. Overall growth and yield was higher with *kharif* than with *rabi* legumes. Higher seed cotton yield was recorded in *kharif* legumes cluster bean (2446 kg $ha^{-1}$) followed by sesbania, lablab, groundnut and green gram intercropped in American cotton (Fig. 3.15.1). In *desi* cotton, seed cotton yield was lower with intercropping than sole cotton 90 x 10 cm (2276 kg $ha^{-1}$) yield.

***Desi* cotton+ legume intercropping in 1:1 ratio**

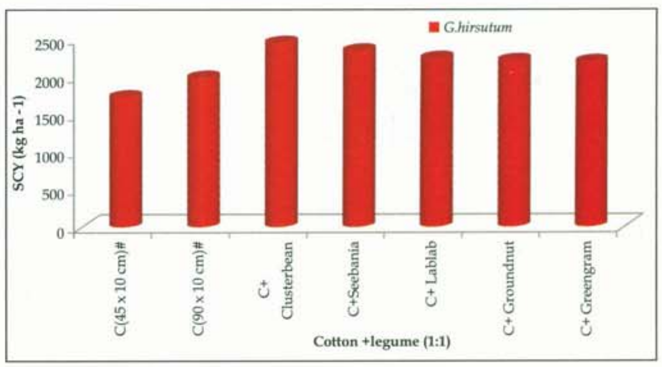


**Fig. 3.15.1: Effect of N fixing legume intercrops on seed cotton yield (SCY) of Suraj variety**

**Coimbatore**

**Alley cropping of perennial legumes with cotton for sustainability**

Three perennial legumes *viz., Desmanthus virgatus* (hedge lucerne), *Medicago sativa* (lucerne) and *Mimosa invisa* (thornless mimosa) were grown as alley cropping with cotton. The recommended spacing of 90 x 60 cm was followed for sole cotton. In perennial legume plot, spacing followed was 90 x 45 cm. Every fifth row was sown with two rows of perennial legume without sacrificing the cotton plant population as compared to sole cotton. The yield attributes and seed cotton yield were not significantly altered in the first year of the study due to perennial legumes. Among the perennial legumes, the growth of Desmanthus was very fast and it produced 15.44 t/ha of fresh biomass followed by thornless mimosa (4.21 t/ha). The growth of Alfalfa was very slow and produced only 0.48 t/ha of fresh biomass during first and second pruning.

**Alley cropping of Desmanthus with cotton**

## 3.16: Conservation Agriculture

### Development of remunerative cotton based cropping systems using conservation agriculture principles under irrigated condition

Field experiment was conducted with cotton-based cropping system using strip plot design. The main plots involved conventional system ($M_1$: Farmer's practice), conservation agriculture (CA) system with minimal land reshaping and partial (50% of residue from above ground biomass) residue recycling ($M_2$) and CA system with 100% residue recycling ($M_3$). For CA treatments, beds and furrow system was used while for the conventional system, ridges and furrow system for cotton and flat beds for other crops was used. The CA plots were maintained on a permanent basis. The sub-plots consisted of four cropping systems *viz.*, $S_1$: cotton - black gram - maize (for grain purpose); $S_2$: cotton - maize (for green cobs) + pigeon pea (strip cropping in 4:2 ratio); $S_3$: cotton - groundnut (for table purpose) + pigeon pea (strip cropping in 8:2 ratio) and $S_4$: cotton - fallow (Control).

Analysis of Cotton Equivalent Yield (CEY) of different cropping systems (2015-16 sequence) indicated that land shaping treatments *viz.*, Ridges and furrows ($M_1$: 4623 kg CEY $ha^{-1}$), Beds and furrows (4261 kg CEY $ha^{-1}$ in $M_2$ & 4513 kg CEY $ha^{-1}$ in $M_3$) had no significant effect on CEY. However, in terms of cropping systems, cotton – groundnut (for table purpose) +pigeon pea recorded CEY of 5007 kg ha$^{-1}$; cotton - maize (for green cobs) + pigeon pea recorded CEY of 4934 kg ha$^{-1}$; cotton - Black gram - Maize (for grain purpose) registered CEY of 4521 kg ha$^{-1}$ (Fig. 3.16.1) which were significantly higher than the conventional Cotton - Fallow system (CEY of 3400 kg ha$^{-1}$). On an average 3.91, 0.98, 5.87, 3.81 and 1.75 t ha$^{-1}$ residue of cotton, black gram, maize, groundnut and pigeon pea, respectively, was produced under $M_3$ and 1.72, 0.47, 2.72, 1.71 and 0.95 t ha$^{-1}$ residue of cotton, black gram, maize, groundnut and pigeon pea, respectively, was produced under $M_2$ and recycled as surface mulch according to treatments in addition to the roots which were retained in the soil.

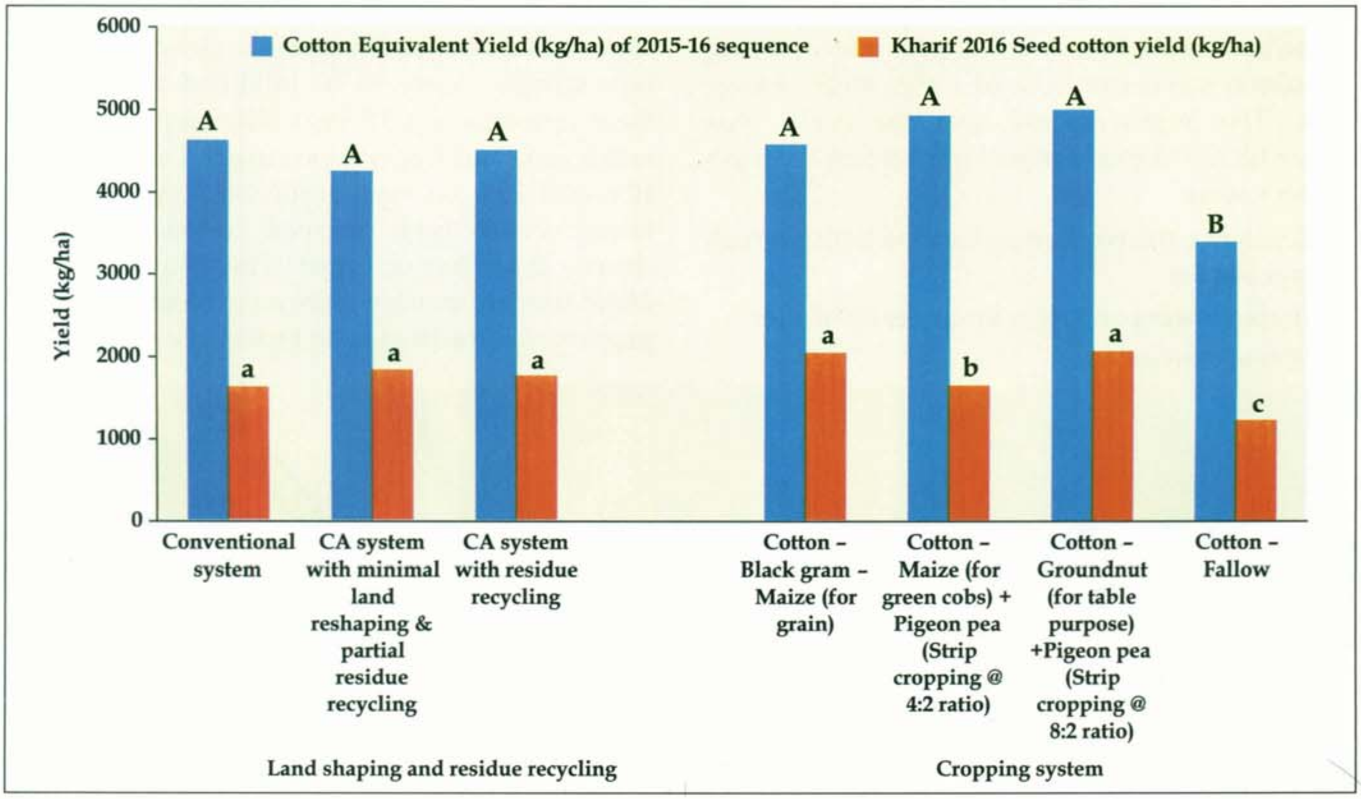


**Fig. 3.16.1: Cotton Equivalent Yield (kg CEY ha$^{-1}$) of 2015-16 cropping sequence and *Kharif* 2016 seed cotton yield (kg ha$^{-1}$)**

***(Different lower case and upper case letter indicate significant difference among treatments within the group)***

## 3.17 : Water Management

### Coimbatore

### Evaluation of structured water for cotton production

Field study was conducted in a split plot design with structured water and bore-well water in the main plot and seven cotton cultivars *viz.*, Suvin, Suraj, Surabhi, MCU 5 VT, Anjali, Mallika Bt and Bunny Bt in the sub-plot. Cotton cultivars responded to structured water irrigation as evidenced from an additional seed cotton yield of 3.87 q/ha across cultivars due to structured water irrigation. Irrigation using structured water also resulted in higher dry matter, nutrient uptake, root cation exchange capacity and boll numbers as compared to bore-well irrigated cotton. The available moisture holding capacity on fourth day of irrigation was 27.1 % with structured water as compared to 25.6 % with bore-well water indicating better hydration due to structured water.

## 3.18: Mechanization of Cotton Production

### Nagpur

The finger type concept of header was found to harvest trash beyond acceptable limits. Therefore, a brush type stripper was developed. The brush type stripper header consists of two rotary brushes for stripping of cotton from the plants and two auger conveyors for collection of the stripped cotton. Brush type header was mounted on the tractor mounted cotton stripper harvester, developed earlier under the project, as a replacement for the comb type header. From the header, the stripped cotton was conveyed through a perforated conveyor to the field cleaner mounted at the back of the tractor and finally after cleaning the cotton was conveyed into a wire mesh storage tank. The improvements over the comb type harvester developed earlier for lowering the trash content, were

1. Replacing the comb type header with a brush type header
2. Slotted lower pan below the auger on header
3. Slotted conveyor

Field evaluation of the brush type stripper was done at ICAR-CICR, Nagpur during January 2017. During the trials, it was found that the brush type stripper was able to harvest cotton from a height of 300 mm and above and the cotton bolls situated below 300 mm height were left unharvested on the plants, mainly because of positioning of brushes at 300 mm height from ground surface. Moreover, the doffers were throwing significant amount of harvested cotton on the ground. Hence, the brush type stripper needs to be modified to overcome these operational problems. The trash content of brush type and finger type stripped cottons were 10.8 and 29% on raw cotton basis, respectively. Hence, brush type stripped cotton was much cleaner than that of finger type stripped cotton. There was not much significant difference in fibre properties of the finger and brush type headers.

**Brush type stripper harvester**

**Brush type header**

**Slotted under cover for conveyor**

## 3.19 : Socio Economic Dimensions of Cotton Farming

### e-Kapas network to connect cotton farmers nationally for technology dissemination

Information and Communication Technology initiatives play a vital role and can help an average Indian farmer to get relevant information regarding crop cultivation, fertilizer application, pest management, processing, marketing, agro-finance and management of farm agric - business etc. The novel extension mechanisms 'e-Kapas Network' was initiated in April, 2012. The project implemented to provide opportunities to the cotton growers to get relevant, location specific, timely agro-advisory services and deliver appropriate cotton technologies to farmers to improve the efficiency of current manual system by saving time, money and making technologies available 'anywhere and anytime' to users. The components of e- Kapas includes farmers' database, FAQs on cotton, content development and recording of voice messages, information delivery as voice calls on mobile numbers, kapas panchang and cotton apps.

### e-Kapas farmers' database

Farmers were motivated to register themselves as 'e- Kapas' beneficiaries through publicity in newspapers, State Agricultural Departments, Agriculture Expos, cooperative banks, NGOs, etc. During the year, from the districts of eleven cotton growing states, 1, 59,948 new farmers were registered. State wise cotton growers registered were as follows: Maharashtra: 1,04,806, Gujarat: 60,247, Madhya Pradesh: 12,269, Orissa: