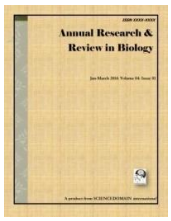

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Production Economics of Surgical Cotton in Mixed Cropping Systems of India

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Author's contribution

This whole work was carried out by author ARR.

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ABSTRACT

Aim: Estimate the economics of surgical cotton production in the natural home of *G. arboreum* cottons and advice the surgical cotton enterpreneurs.
Methodology: Field experiments, on farm trials, gin/surgical cotton unit surveys were conducted and economics was calculated from the relevant data**.**
Results: National bio-diversity authority of India (NBDAI) rules for large scale commercial exploitation doesn't permit for surgical cotton production from the native cottons. *G. arboreum indicum var*. LD 230 and RG-8 could be grown commercially in the north eastern India under slash and burn system. *Yaganti* in *Mungari* cotton tract and MDL ABB-1 (selection from *G. arboreum cernum local var. karbi under NATP RCPS-9*) in *Gaorani* cotton tract of Andhra Pradesh state, G-27, RG-8, LD-491, Lohit, LD-230, *Karbi* cotton (local *G. arboreum cernum*) and *Phule Dhanwantari* in Jalgaon-*Khandesh* and *Amraoti, Yeomal* of *Vidarbha* region of Maharashtra states are few ready to use surgical cotton varieties for commercial production. Limitations of *G. arboreum cernum* is shy boll bearing, photo sensitive nature, fewer bolls, lower yield and servere grey mildew disease incidence in September month. Limitation of *G. arboreum indicum* cultivars were small boll size, boll worm damage, shattering of matured cotton, frequent pickings, lower GOT and grey mildew disease incidence results in less returns in market. Surgical cotton processing centres were located in west, central and south India which can encourage commercial production under contract farming can give a profitable returns of US $ 1000 ha^{-1}. Premium to the extent of 30% is needed

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due to absence of Bt trait (19%) and higher ginning out turn (11%) outside north eastern India and north coastal Andhra Pradesh in order to compete with Bt hybrid cotton.

Conclusion: Meghalaya, Assam, Mizoram, Tripura and north coastal Andhra Pradesh, India which were the natural home of *G. arboreum cernum* and *G. arboreum indicum* cottons respectively having competitive price and yield advantage in by default organic conditions, besides premium quality and economical for surgical cotton production.

Keywords: Absorbent cotton; Assam comilla cotton; Bengal desi cotton; micronaire, premium quality; Punasa/Ponduru cotton; surgical cotton.

1. INTRODUCTION

Recent increase in the demand for surgical cotton was due to increase in the general awareness and corporate health care facilities in rural and urban India. Limited processing and double digit margins were encouraging the new entrepreneurs at a capital investment of 0.19 million US $ with annual margin of 27% [1]. Although, branded Indian export houses were continuously exporting since 1960 to Japan, USA, EU and China [2], but they had entered into problems in recent years due to shortage of raw materials [3]. Bt hybrid cotton totally replaced indigenous cotton production 9.0 to 4.0 *lakh* bales during 2002-2011 [3] except in north eastern states and north coastal Andhra Pradesh. Minimum support prices (MSP) were increased by Government of India which were not available in surgical cotton local markets and farmer's were expecting 30% premium due to lack of *Bt* trait [4] and higher ginning out turn due to lower seed weight, which were not in favour of farmers. Central Institute for Cotton Research, Nagpur had developed *G. arboreum* cotton variety RG-8 suitable for surgical purposes in *Bt* background [5], but It would be impossible to get it released in India being indigenous cotton. Very coarse/ higher micronaire is desirable for surgical cotton is a myth [6] and any cotton with 10 sec absorbency & sinking time with water holding capacity > 23g/g cotton, which can be achieved by de-waxing and carboxilation [7,1]. Leading international brands however, uses high micronaire, very coarse Assam *Comilla* (7-8 mic) / *Bengal desi* (6.8-7.2 mic) cottons for surgical cotton production due to very few *neps* formed during processing [8]. Branding helps to identify the quality assurance with realization of double price in international market. *Assam Comilla* cotton is traded much below the MSP (US $ 430 ton^{-1}) mainly because of absence of procurement centres of cotton by Cotton Corporation of India in north-eastern states [9]. *Bengal desi* (*G. arboreum cernum*) cotton area production and productivity (Table 1 and Figs. 1 and 2) in north east dominating with Meghalaya, Assam, Mizoram and Tripura, in *Jhum* cultivation is unaffected by Bt hybrid cotton invasion. Now it is economical to procure from north east and transport and gin at central India with lower price to that of *Bt* hybrid cotton i.e. US $ 2381. Assam *Comilla* cotton cultivation can be encouraged with incentives which can lead to better employment generation and increase in farm income.

Ginning training Center (GTC) of Central Institute for Research on Cotton Technology (CIRCOT) at Nagpur ginned 25 tonnes Assam *Comilla* cotton at Nagpur commercially competing with the Bt hybrid cotton pricewise despite of higher transportation cost due to prevailing sub optimal prices. Similarly, *Punasa* cotton (*G. arboreum indicum*) is also suitably available for export quality surgical cotton (Table 4-5). However, commercial exploitation of these land races outside their home of production is subjected to the laws of the recently created National Bio-diversity Authority of India (NBDAI). Therefore, Central Institute for Cotton Research, Nagpur has launched a research project for screening suitable genotypes of improved short staple cottons for commercial cultivation in TMC MM I [10] during 2012-17. Although, surgical cotton variety seeds can be made available by the SAUs to farmers which may not be economically feasible to bye back at 30% premium by young entrepreneurs. Therefore, a possible way out is to procure cotton lint from the natural home of their production, ginning and crushing the seeds for oil onsite through one step by middle men which can reduce transportation cost by 65%. Entrepreneurs has to outweigh transportation cost US $ 463 $tonn^{-1}$ *Vs* local ginning. Agro economical study was conducted on *G. arboreum* cotton production sites which were extrapolated to current US $ prices for benefit of farmers, policymakers and young entrepreneurs to identify the optimum surgical cotton varieties, location and prices.

1.1 Site Character

G. arboreum cotton was commercially grown on or before expansion of Bt hybrid cotton were selected for this study.

1.2 *Gaorani* Cotton Tract, Adilabad (TS), India

Adilabad has got 16% of the area under cotton of Andhra Pradesh state of Central India. Experiments were conducted at Agricultural Research station, Mudhol (18 58° 77 55° E) of Professor Jayashankar Telangana State Agriculture University, Telangana State, India. This site had both shallow red soils and medium deep gravelly Vertisols. Normal annual rainfall of the district was 1045 mm (Table 2).

1.3 Srikakulam (A.P)

On farm trials were also conducted at villages in *Ponduru*, *Amudalavalsa*, Srikakulam (18°-20' and 19°-10' N and 83°-50' and 84°-50' E) district in north coastal Andhra Pradesh of south eastern India (Table 3).

Table 1. *C*otton in the NE states of India, 1997-98

	Area 000 ha	Production 000 bales	Average yield lint kg ha^{-1}
Assam	1.7	0.8	80
Manipur	0.1	0.1	170
Meghalaya	7.6	5.5	120
Mizoram	1	2.7	460
Nagaland	0.2	0.3	260
Tripura	1.1	1.6	250
Total	11.7	11	160

Table 2. Rainfall monthly (mm) at Mudhol (Adilabad, TS)

	June	July	August	September	October	Total
2007	142	110	220	260	32	764
2008	144	207	358	129	11	849
2009	5	180	188	116	60	549
2010	98	408	422	299	110	1337
2011	101	297	306	150	5.3	859
Average	98	240	299	191	44	872

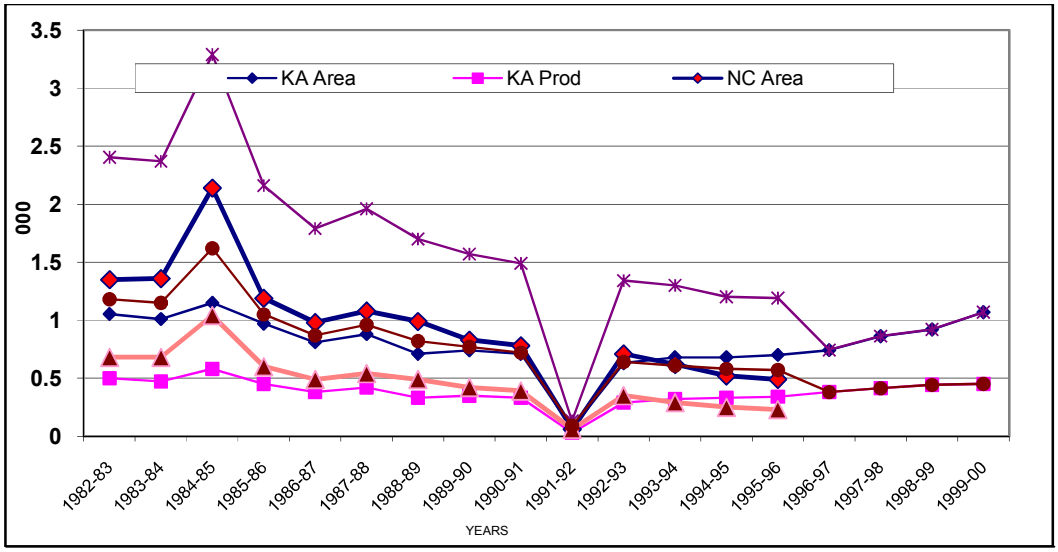

Fig. 1. Area, production and productivity in hill zones of Assam

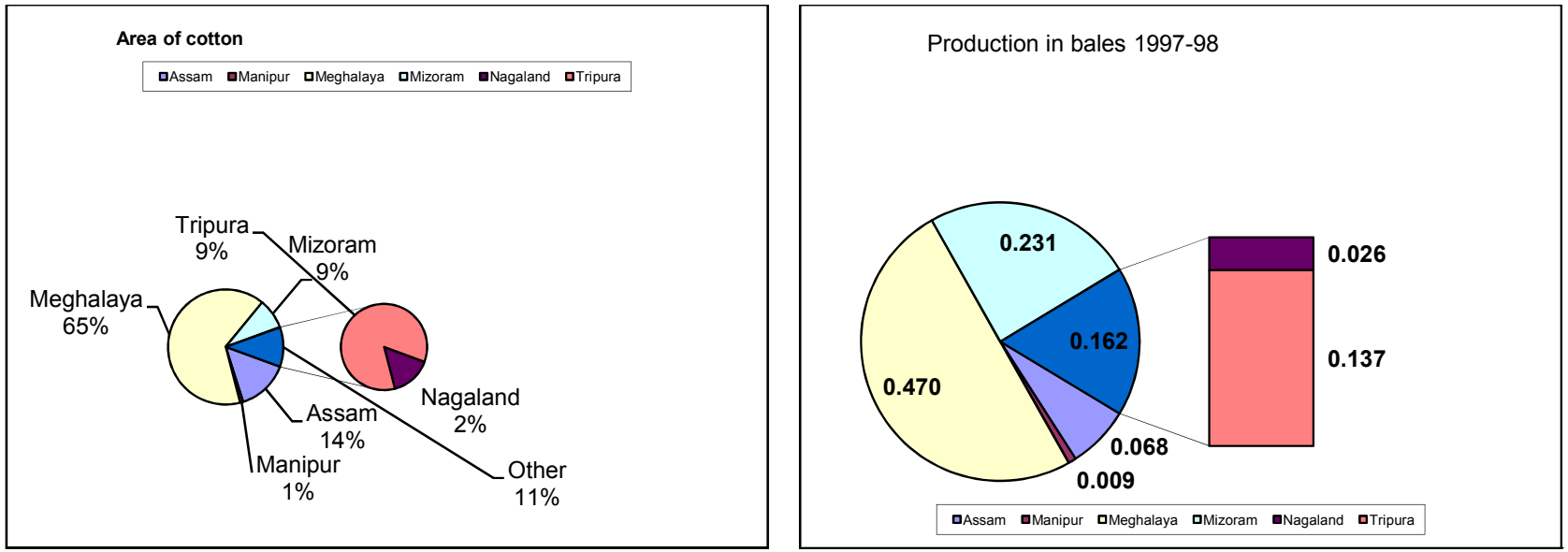

Fig. 2. Area and production of cotton NE Indian states 1997-98

Cotton in the NE states of India, 1997-98. Directorate of Economics and Statistics, North Eastern states, Jorhat, Assam

Table 3. Rainfall monthly (mm) at Srikakulam (A.P)

	May	June	July	August	September	October	November	Total
2007	87.2	364	164	106.5	176.4	314	0.6	1213
2008	88	72.7	189	220	254	28.2	8.7	861
2009	26	99.3	216	162.5	145.4	123	85.2	857
2010	173	142	237	263	208	333	179	1535
2011	93.1	121	169	277	181.3	31.3	0.0	873
Average	93	160	195	206	193	166	55	1068

Table 4. Rainfall (mm) and rainy days at Diphu, Assam

Month	Normal	2011-12	Difference	No. rainy days
April	121	67	53	5
May	141	164	-24	15
June	191	297	-106	16
July	214	102	112	11
August	210	141	69	10
September	185	202	-16	12
October	99	20	79	1
Total	1160	994	166	70

1.4 *Jhum* Cultivated Karbi Anglong District Diphu, Assam

Onfarm trials were also conducted in *Karbi Anglong* district of Assam state, in north east India. The soils were sandy loams with steep slopes. Climatic features were given (Table 4 see above).

2. MATERIALS AND METHODS

Seeds were selfed, hand ginned and planted at the experimental sites at 0.6 x 0.30 m in Adilabad (TS) and broadcasted as mixed cropping with sesame/green gram in *Jhum* cultivation at *Diphu* (Assam)/*Ponduru*. *Punasa* cotton is often broadcasted as annual crop in the back yards of weaver's along the coastal red lateritic and sandy loam soils. *Hill* / red cotton however, hand dibbled in groundnut / green gram mixed cropping in *Ponduru* mandal of Srikakulam (A.P). Hill cotton is often ratooned with 30% higher yields and earliness besides drought mitigation. Fertilizer dose of 60:30:30 kg ha^{-1} N: P_2O_5: K_2O were applied only at Adilabad (TS) and Srikakulam (A.P) as there is no fertilizer supply in north eastern India. Crop was harvested at the maturity weighed and calculated per unit area. Need based plant protection measures were followed as per the requirement. Fibre properties were analysed by HVI instrument at GTC, CIRCOT, Nagpur. Fish jaw combing is a local practice at Srikakulam for cleaning cotton, removing short fibres besides ginning by jerk on a wooden board with ruler and bow for opening cotton.

3. RESULTS AND DISCUSSION

Ponduru cottons were suitable for surgical cotton in general and *Punasa* cotton in particular for premium quality range (Table 5) doesn't need any bleaching. Lower cost of production, absence of MSP/ competitive market forces besides cheaper labour availability for production, ginning and cleaning are ideal conditions for surgical cotton industry. Contract farming for lint supply is good offer for local farmers/ entrepreneurs through *khadi* and village industries (KVIC) controlled local weaver's co operative societies like *Andhra Fine khadi Karmika Sangham (AFKK)* at Ponduru and *Srikakulam Fine khadi* at Srikakulam (A.P), India is organizing production and processing of these cottons since decades. Seeds after cleaning and ginning are used by local farmers as animal feed which had ready market and nutrients are recycled in local farms as farm yard manure. However, these cottons may be considered as land races but they were being commercially produced and exported to Japan and east European countries since decades by middle men even before the establishment of NBDAI.

3.1 *Ponduru* Cotton Production Systems

Punasa cotton is predominantly cultivated only as pure crop in coastal sandy clay loam soils.

This area is controlled by *Srikakulam Fine Khadi* Society located behind court complex with its retail outlets located in Srikakulam town and villages. Limited extent of red cotton is also grown by them under high rainfall area. The farmer's economy is maintained with high plant density usually grown as back yard crop in red, sandy loams and black soils for ready to spin into yarn by rural women. These cottons are under fertilized, fertilizer responsive (Table 6) often under neglected management. *Punasa* cotton is suitable as direct introduction in to surgical cotton cultivation with minimal care. Fertilizer application and advance payments will be more useful under contract farming (Table 6).

3.1.1 Red soils

G areboreum indicum cultivars. Red and hill cottons are predominantly cultivated as mixed crops with wider spacing of 1x1 m a part dibbled in mixed ground nut crop and often rationed to face the competition from mixed ground nut / sesame green gram and black gram. Absence of basal fertilizer application, interculture operations, rain water conservation, harvesting and recycling as supplemental irrigations besides grey mildew control measures in August month are constraints in cotton production. Small boll size (2 g) and large number of bolls (400 plant^{-1}) requires frequent pickings by family labour. Animal pennings and application FYM are only avenues (Table 7) presently used to maintain soil fertility, besides top dressing of DAP + urea mixture one 50 kg bag / acre application after September rains or after harvest of mixed crop is a local practice (Table 8). Basal fertilizer application is avoided due to fear of competition. Top dressing of urea found to be very effective under poor N supply. Grey mildew damage is very severe after August rains for ratoon cotton besides occasional losses from boll worms. Ratoon crop has to survive in severe summers, often pruned to 2-3 main branches above 1 feet from the ground level. Lower plant stand is also a constraint. Very high expenditure on manual hoeing and hand weedings can pave way for post emergence herbicides viz. PyrithiobacNa + Quizalofop ethyl each @0.035 kg a.i.ha^{-1} at 30 DAS to reducing cost of production (Tables 6-7).

3.1.2 Medium black soils

Ratooning of hill/ red cotton is producing more than the seed crop. Plant stand of ratoon crop is sufficient but difficult to maintain under severe summer in the absence of irrigations. Lower moisture holding capacity of the soils, boll worm's damage and grey mildew are limitations which need attention (Table 9). Only 1st picking of cotton is available as that year faced very severe drought with 30% normal rainfall.

Table 5. Fibre properties of *Ponduru* cottons at Srikakulam (A.P)

Cotton land races	Category	2.5% span length (mm)	UR%	Micronaire (µg/inch)	Bundle strength tenacity (g/tex)
Red/ *Errapatti*	Fish combed	21.7	50	6.7	19.2
Hill/ *Konda patti*	Fish combed	23.7	50	6.4	20.9
Punasa patti	Fish combed	18.9	54	6.4	17.9
Punasa patti	Non fish combed	19.3	54	6.4	17.9
Hill/ *Konda patti*	Non fish combed	22.4	49	6.2	20.7
Red/ *Errapatti*	Non fish combed	21.2	50	6.2	18.0

Table 6. *Ponduru* cottons in coastal sandy loam soils

Performance in mixed cropping systems	Seed cotton yield kg ha^{-1}
Red cotton pure crop with bio-fertilisers.	386
Red cotton mixed crop with *ragi* and bio-fertilisers	**595**
Red cotton mixed crop with black gram and bio-fertilisers.	194
Ampolu village red color pure crop no fertilisers	250
***Biru Singa puram* 2nd year red ratoon sandy clay loams**	**1125**
Kishtappa peta red cotton seed crop	286
Seed crop *Punasa* cotton	350
Seed crop *Punasa* cotton with bio-fertilisers.	**519**
***Punasa* cotton with 50 kg urea/acre application.**	**950**

3.1.3 Sandy loam soils

Ratoon crop of hill/ red cotton is producing more than seed crop, therefore, wide spread ratooning is followed which is leading to more grey mildew and pink boll worm problem. Lower moisture holding capacity of the sandy loam soils is a severe limitation where mixed cropping is followed (Tables 10 and 11).

Assam *Comilla* cottons are 3rd in order of profit for both farmer's and entrepreneur's under mixed farming situations of *Jhum* cultivation alongwith green gram with no external inputs being low yielders they were next only to LD 230 and RG-8 (Tables 12, 13). Premium quality pricing if paid can be expanded and second quality by LD 230 and RG-8 if NBDAI restricts its commercial cultivation. Although improvement of these cottons were initiated by breeders but maintaining higher boll weight and coarseness is difficult except under hybrid conditions as observed by at ARS, Mudhol [11] which was notified as MDL ABB-1 and CICR, Nagpur hit the headlines and attracted attention of cotton world on the cotton productivity [12]. Pure line selections were made within local ecotypes at RARS, *Diphu*, *Karbi Anglong* district, Assam, India and were tested in NATP project RCPS-9 but seeds could not be maintained by respective breeders.

3.2 *Gaorani* Cotton Tract

Gaorani cotton tract was once the home of *desi* cottons covering two states of Telangana and Maharashtra states. This tract is now gets severe competition with Bt hybrid cottons although they may not give returns of 1000 US $ ha^{-1} but that is expected for a fairly good standard of living for farmers. This target can be achieved by premium quality LD 491 followed by Lohit and G-27. After this MDL 1875, K-10, LD-230, AKA-7 and AKA 8401 can be profitable in second quality for national requirement (Tables 12, 13). However, in the absence weighted premium for Bt trait and ginning out turn they cannot be competitive with Bt hybrid cotton.

Table 7. Ponduru cotton onfarm trials in red soils underground nut mixed cropping system at Nimmalavalasa, Sirkakulam Dist (A.P)

	Fertilizers applied Kg ha^{-1}			Organic manures	Sheep pennings	Yield q ha^{-1} Seed cotton/ Ground nut
Crop	N	P	K	Cart loads ha^{-1}	Days/ Year^{-1}	
Ground nut						5
Red cotton	12.3	29	50	12	6	10
Hill cotton	40	29	0	7	3	6

Table 8. *Ponduru* cotton onfarm trials in red soils at Nimmalavalasa, Sirkakulam Dist (A.P)

Treatments	SCY kg ha^{-1}	Mixed crop Ground yield kg ha^{-1}	OC%	Soil available N ppm
Red cotton with no fertilizer	334	501	0.44	147
Red cotton 40 kg N ha^{-1}	375	538	0.45	
Hill cotton with no fertiliser	250	501	0.45	147
Ratoon crop with no fertiliser	167	250		
Hill cotton ratoon crop DAP + Urea 1 bag/ acre in September	334	358		

Table 9. Ponduru cottons in Shallow black soils Madhupam, Sirkakulam Dist (A.P)

Treatment	SCY kg ha^{-1}	OC%	Available N ppm
Red cotton seed crop-chillies	375	0.22	56
Red cotton ratoon crop.	217	0.59	35
Hill cotton seed crop with biofertilisers and urea as top dressing.	217	0.39	161
Ratoon crop with urea +potash	375	0.32	42

Table 10. Ratoon yield kgha^{-1} in sandy loam soils Narsapuram, Ponduru, Srikakulam Dist (A.P)

Treatment	Seed cotton	Green gram	Horse gram	OC%	Available N ppm
Hill cotton with green gram and biofertilisers.	63	56	34	0.22	52.5
Hill cotton with 25 cart loads FYM and 58 kg N ha^{-1} as basal dose with biofertilisers	750	1000	250	0.7	42

Table 11. Seed crop at Kishtappa peta village, Ponduru (Srikakulam Dist) A.P

	Fertilizers applied Kg ha^{-1}			Organic manures	Sheep pennings	Seed cotton Yield q ha^{-1}
Crop	N	P	K	Cart loads ha^{-1}	Days/ Year $^{-1}$	
Hill cotton	50	29	0	7	3	7.0

Table 12. *G. arboreum* cottons yield at Diphu, Assam (India)

	Seed cotton yield kg ha^{-1}	Gross returns realized by entrepreneur ha^{-1} US $			2.5% Staple length (mm)	Micronaire (µg/inch)	Bundle Strength (g/tex)	Uniformity Ratio %	Ginning percentage
		Farmer	Using local gin	Using factory gin					
Karbi local	639	367	95	118	18.1	7.8	14.8	55	46.2
LD 230	904	519	134	167					
RG-8	823	472	122	152					
MDL 1875	578	332	86	107					
AKH-5	560	321	83	104					
AKA 8401	560	321	83	104					
Lohit	540	310	80	100					
Y1	504	289	75	93					
K10	467	268	69	86					

Table 13. Fibre properties of *G. arboreum* cotton varieties at ARS, Mudhol, Adilabad (TS)

Varieties	Yield kg ha^{-1}	Gross returns realized US $ ha^{-1}		2.5 span length (mm)	UR%	Micro naire (µg/inch)	Bundle strength (g/tex)
Year	Mean	No premium	30% Premium	Mean			
G-27	1237	1031	1340	18.2	54.5	6.1	16.3
Lohit	1119	933	1212	20.1	53.0	6.3	16
MDL-1875	1022	852	1107	25.6	50.3	5.5	21.4
K-10	1015	846	1100	26.0	49.3	5.5	21.4
LD-230	991	826	1074	19.6	51.0	5.5	15.1
AKA-5	982	818	1064	25.1	50.0	5.5	19.3
LD-491	954	795	1034	21.1	52.0	6.8	16
Hill (*Kondapatti)*	850	708	921	22.4	49.0	6.2	20.7
RG-8	835	696	905	19.3	52.0	6.9	14.9
Red (*Errapatti*)	800	667	867	21.2	50.0	6.2	18
Punasa patti	600	500	650	19.3	54.0	6.4	17.9
CD±5%	287	239	311	1.9	2.79	0.6	1.91

Table 14. Agronomical performance *G. arboreum* cottons in medium deep black soils, Nagpur (M.S)

Year	Yield kg ha^{-1}	Gross returns US $ha^{-1}		2.5 span length (mm)	UR%	Micro naire (µg/inch)	Bundle strength (g/tex)
		Actual	Premium				
G-27	1162	968	1259	17.9	55.3	6.1	15.7
RG-8	973	811	1054	18.7	52.0	6.1	14
LD-491	953	794	1032	20.5	52.0	6	14.9
Lohit	1056	880	1144	19.8	53.0	5.8	15.4
LD-230	1013	844	1097	19.6	51.0	5.5	15.1
Karbi	1139	949	1234	25.1	49.0	5.1	20
CD±5%	346	288	375	1.4	2.2	0.5	1.65

Mungari cotton tract was also once a traditional home of *G. arboreum indicum* cotton production where serious replacement is taking place with aggressive marketing strategy by Bt hybrid cotton companies under competition free environment. *G. arboreum indicum* cotton variety *Yaganti* is locally developed and readily available for farmer's use with surgical quality.

Vidarbha and *Malwa* regions of Central India were once commercial production centres for *desi* cottons were totally replaced by Bt hybrid cotton except pockets in Jalgaon of *Khandesh region, Melghat* of Amraoti and Murtizapur of Akola (MS) in *Vidarbha* region. Y-1, JLA-794, Jawahar Tapti, AKA-5 were used by local surgical industry for surgical cotton production. MPKV, *Rahuri* recently released *Phule Dhanwantari*, which produced higher seed cotton yield 1418 kg ha^{-1} over Y-1 1279 kg ha^{-1} and JLA-794 1292 kg ha^{-1} [7,13]. It had absorbency of 1.9 sec and sinking time 2.0 sec. with water holding capacity 26.7 g /g of cotton as compared to Y-1 6.5 sec, 8.5 sec. and 25.0g /g of cotton, respectively used for surgical cotton production for local requirement. G-27, RG-8, LD-491, Lohit, LD-230 and *Karbi* cotton were profitable with weighted premium to local farmers in medium deep soils (Table 14 see above).

4. CONCLUSION

It can be concluded as the entrepreneurs of central India are planning to produce on their own or import from north east Indian states is not economical instead of it can be contracted to the farmers for supply of locally ginned lint. This would be more cheaper besides entrepreneurs can concentrate on quality control and market expansion.

5. SUMMARY

Premium quality surgical cotton with a competitive price advantage is in the natural home of *G. arboreum cernum/ indicum* cottons. Processing centres can encourage LD 230 and RG-8 in north east India under *Jhum* cultivation,

Yaganti in *Mungari* cotton tract, MDL ABB-1 in *Gaorani* cotton tract, G-27, RG-8, LD-491, Lohit, LD-230, *Karbi* cotton and *Phule Dhanwantari* in Jalgaon-*Khandesh* and *Vidarbha* region of Maharashtra states under contract farming.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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