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CONSTRAINTS TO COTTON PRODUCTION IN INDIA

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FOREWORD

Cotton cultivation, processing, marketing and trading has been the mainstay of millions in India for centuries. Cotton has a unique place in the Indian Independence movement, that started following the systematic destruction of the handloom industry by the imperial mill sector and the consequent unrest among the vast populace displaced. Since independence the country has transformed from being a net importer of raw cotton into self sufficiency and even a marginal exporter of raw cotton. Besides, cotton yarn, fabric and garment exports add immensely to the nation's foreign exchange. But, the average productivity of Indian cotton is one of the lowest in the world and is a cause for concern, as millions of people depend on cotton cultivation and their economic well being is decided by the crop's performance and productivity. But, the National Agricultural Research System which has been instrumental in this transformation by developing more than 100 varieties and hybrids, crop production and protection technologies and packages suited for specific situations has demonstrated the productivity potential several times the field average. The transfer of potential has been hampered by several factors, which are generally referred to as 'constraints to productivity'. The constraints can be bio-physical or socio-economic and at field (micro) level and community (macro) level. This bulletin is an attempt to document the types and extent of these constraints collected from primary and secondary sources and quantified. The information will be an useful input in technology generation and transfer and planning.

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(Dr.C.D.Mayee)
Director

Introduction

Cotton cultivation in India signifies total diversity in vastness, spread, agroclimate, farming methods, cropping systems, planting and marketing seasons, varieties, duration, yield, quality and costs and returns. In India, the crop occupies more than 9.2 m.ha and its share in world cotton area is 27 per cent and supports 60 million people directly and indirectly through its production, processing, marketing and trade. India's textile industry account for 7% of Gross Domestic Product, 20% of industrial output and 38% of export earnings and consists of all the three sectors - mills, powerlooms and handlooms.

India is the only country in the world that grows all the four cultivated species of cotton (Table 1).

Table 1. Specieswise distribution of cotton area and production (1997-98)

Species of *Gossypium*	Varieties		Hybrids		
	Area (%)	Production (%)	Types	Area (%)	Production (%)
Hirsutum	36	40	H x H	35	40
Barbadense	0.2	-	H x B	4	7
Arboreum	16	8	Diploid/Desi	>1	1
Herbaceum	8	4	hybrids		
Total	60	52	Total	40	48

The country is divided into three main cotton growing zones, the northern *G.hirsutum* and *G.arboreum* zone in the States of Punjab, Rajasthan and Haryana, accounting for about 1.9 million hectares (Table 2), the major central *G.hirsutum*, *G.arboreum* and *G.herbaceum* zone in the States of Gujarat, Madhya Pradesh and Maharashtra with 5.4 million hectares, the composite southern *G.hirsutum*, G. *arboreum*, *G.herbaceum* and G. *barbadense* zone in the states of Andhra Pradesh, Karnataka and Tamil Nadu accounting for about 1.8 million hectares (Gillham, *et al., 1995).*

Table 2. Zonewise distribution of cotton area, production and productivity (decade average)

Zone	Area (%)	Production (%)	Irrigated area (%)	Hybrid area (%)	Yield (kg/ha)
North	21	25	99	<1	327
Central	57	49	22	50	281
South	22	26	30	55	361
All India	100	100	25	40	323

These are not mere geographical/agro-climatic zones, but reflect the socio-economic characteristics of the rural populace that has taken up cotton cultivation as commercial venture in North Zone, low input and high risk agriculture in Central Zone and as component of the much diversified cropping scheme in South Zone.

Productivity Potential and Estimated Yield Gap

India has the largest area under cotton, but its cotton production is just 15.8 million bales, much lower for the vast area, the crop occupies. The major hurdle is the low productivity of the crop being cultivated in predominantly small holdings. Yield in small holdings are often depressed because of competition among crops for land and labour, leading to lack of timeliness in field operations and to difficulties in weed control, insect control and picking (Hamdy, et.al, 1994). Table 3 shows the general cotton profile of the major producers.

Table. 3. Area, production and productivity of cotton in major countries (1998-99)

COUNTRY	AREA('000 ha)	PRODUCTION ('000 m.t.)	YIELD (kg/ha)
China	4400	4398	1000
USA	4339	3029	698
USSR (Former)	2528	1441	570
India	9170	2809	306
Pakistan	2900	1415	488

Source: Cotton – World Markets and Traded, April 1999. USDA, Washington

These cotton giants apart, many other countries, though their area may be modest to negligible, have attained yield levels much higher than that of India. Mentioned below are the yield levels, which can be considered to be the highest in the world:

COUNTRY	Yield (kd.Lint/ha)
Israel	1814
Australia	1327
Syria	1270
Turkey	1144
Mexico	947
Greece	898
Egypt	816

Thus, comparing the international performance it could be concluded that Indian cotton production and productivity compares very poorly amongst the major producers. The production potential and constraints are unique to the regions and systems of cultivation. North zone, being more homogenous in terrain, weather, resource endowment, varietal discipline, agrotechniques, cropping pattern, input use, yield realised, marketing and farmers' enterprise, can easily be treated as a single 'entity' for all analytical purposes. It is not so in Central and South zones as cotton cultivation vary widely in terms of agro-climate, species diversity, farm endowment, varietal proliferation, cropping system, crop rotations, input use, factor and product market, state policies, etc., to be bracketed together for any meaningful analysis.

Districtwise yield data collected for 30 years and the yield gaps across the districts as a difference between the long term average yield and potential yield for the representative varieties showed that there exists a vast scope for enhancing the productivity by bridging up the possible yield gap alone as seen in the Table 4. The lower limit of the yield gap column of central and southern zones approximates to the rainfed cotton and higher limit to the irrigated counter part. While the genetic/ agronomic potential cannot be replicated in farmers' fields, even if one-third of the existing gap is bridged, which is very much feasible and realistic, it will go a long way in improving the cotton economy: The factors that contribute to the gap are many - physical, biological, social and economical.

Table 4. Statewise potential and the existing yield gap (lint in kg/ha)

S.No	State	Representative genotypes	Contribution to state production (%)	Potential yield	Yield gap across the districts
1	Punjab	F414/F1054, J34/F846 Bengal desi	90.71 9.21	1200 1000	700-800
2	Haryana	H777 ,J34/F846 Bengal desi	88.00 12.00	1000 800	600-650
3	Rajasthan	J34/RST-9 Bengal desi	71.00 23.00	1000 800	700-775
4	Gujarat	H6 V797/Digvijay	60.50 39.50	1000 300	150-750
5	Madhya Pradesh	H6/JKHy-1 1007/ LRA5166/K2 Desi	41.38 27.24 22.76	600 500 400	300-500
6	Maharashtra	NHH44 LRA 5166 AKH-4/AKA 8401	35.36 28.21 18.57	500 400 300	225-350
7	Andhra Pradesh	MCU5, JKHy- I/H4 MECH 1&11, LK8611L389 LRA 5166	23.60 71.91 4.04	800 600 500	400-650
8	Karnataka	DCH32 NHH44 Jayadhar/ Suvodhar	48.84 5.56 6.67	1200 800 300	200- 1000
9	Tamil Nadu	DCH32, TCHB2 MCU5, LRA5166	12.72 81.81	1200 1000	150-900

Source for potential yields: Cotton Corporation of India, Mumbai.

Identification and quantification of types and levels of constraints

With varied agro-climatic conditions, and location specificity, the yield potential varies with states. The constraints documented here are those collected from field survey, secondary sources and opinion elicited from experts and administrators involved in cotton research, extension, development and policy planning. Accordingly the constraints are classified into micro (field level), macro (national, zonal and state level) constraints. The field data were collected from sixty farms in Thanjavur district in 1992 during farm experience training, 320 cotton farms from the districts of Yavatmal (1994-95), Adilabad (1995-96), Khandwa, Khargone and Dhar districts (1997-98) and sixty farms in Sirsa (1998-99) during socio-economic farm surveys.

Micro level constraints

Field constraints (those can be decided/amended by the farmer ego selection of seed, choice of variety, time of sowing, spacing, quantity of inputs, etc.) identified were multiplicity of genotypes, use of non-certified seeds, cultivation of F2 seeds, non-adoption of proper spacing, more than recommended number of sprays, less than recommended quantity of fertilizer use, tied up credit and unscientific plant protection (Table 5).

Seed constraints: The present coverage under certified seeds is only 35%. Concrete efforts are needed to ensure that quality seed is made available at a reasonable price. The public and private sectors need to playa complementary role in this endeavour. The cost of hybrid seed production can be reduced by the adoption of GMS and CMS system. Further it can be supplemented by promoting a network of seed villages in case of varieties, so that cheap and quality seed supply can be assured in the proximity with one variety villages. Certified seed availability in adequate quantities on time is a problem often faced by the cultivators. With mushrooming of seed companies, research varieties are flooding the market and irrespective of the resources at their command, there exists a 'hybrid maniac' among farmers. Even as efforts are taken to meet the demand, pricing of seeds need to be streamlined.

Acid delinting in cotton witnessed total discontinuance (Discontinuance is the decision to reject the technology after having previously adopted it) in a study of rice fallow cotton in Thanjavur due to complexity in the process that involves buying of loose quantities of chemicals, taking it home safe in public transport and adherence to strict timing in the absence of an alarm clock. Instead, the farmers wanted already delinted seeds or community acid delinting or an alternative process.

Constraints for timely sowing: The time of sowing in rainfed cotton is ostensibly monsoon dependent. In nearly 55 per cent of the sample farms, sowing was decided totally on onset of monsoon. While the basic problems of rainfall and unsuitable soil could not be overlooked, some contingency measures can be thought of, such as provision of one protective irrigation at a critical stage that augments the yield significantly. This can be done through a network of community wells for irrigation. Wherever possible, micro irrigation has to be introduced through cheaper institutional credit.

Under irrigated condition, timely release of canal water will ensure timely sowing, for which either strong coordination between ministries is warranted or agriculture and irrigation may be brought under one ministry. Ridge and furrow system of irrigation with advice to irrigate only alternate furrows has to be advocated and enforced in place of flat bed method. If timely release of water is totally not possible, community tube wells should provide water for taking up timely sowing.

Soil constraint: Cotton is grown on a variety of soils ranging from well drained deep alluvial soils in the north to black calyey soils of varying depth in central region and in black and mixed black and red soils in south zone. Cotton is semi-tolerant to salinity and sensitive to water logging and thus prefers well drained soils.

With more than 26 per cent of the crop area of the sample farms cultivating the crop in shallow soil, it accounted for a major natural constraint next to uncertain rainfall and weather. Compounding the difficulty was poor crop stand due to lack of proper spacing and population especially in case of varieties. Another factor that adds to the difficulties of unproductive soil is the tendency to use less than recommended dose of fertilizers because of the risk inherent in intensive cultivation under uncertain weather. Desi and *hirsutum* varieties rather than hybrids give a stable performance in such situations. While farmers have to be disuaded from cultivating hybrids under resource poor condition, simultaneous efforts have to be undertaken to evolve genotypes and technologies suited to these problem soils.

Varietal multiplicity/proliferation: Varietal proliferation is indeed a major menace in maintaining purity, arresting pest load and extending technologies. The farm level data showed that in general the area under cotton to total farm area has declined over years, but the ratio of hybrids to farm cotton area is increasing especially in Central and Southern zones. The district level data too corroborate the extent of threat of varietal proliferation at farm level. In the socio-economic survey done in Maharashtra and A.P., it was found that in a sample of 220 farms, more than 35 genotypes were cultivated, though more than 70 % of the area was under any three of the proven genotypes like PKVHy - 2, NHH-44, MECH 12, RCH - 1 and LRA.5166 in all the farms. The contingent plan in this varietal combination is that one or two robust genotypes with assured performance and one or two research varieties with unknown performance will ensure an average yield in the risky environment. One phenomenon uniformly observed was that LRA.5166 in case of Maharashtra and A.P and Khandwa.2 in case of M.P invariably figured in this combination as **yield stabilisers.** Farmers alluded that when hybrid performance is uncertain in adverse conditions, be it copious rainfall or severe drought, these varieties relatively performed well stabilising the income. Thus, the average yield of hybrids was higher and also was the coefficient of variation against the reverse in case of varieties. While hardly 15 per cent of the farms were single variety cultivating ones, the rest were all cultivating multiple varieties. On an average each farm has cultivated 3-4 genotypes and across the sample it was found that more than 35 genotypes were in cultivation and the number of genotypes increased with farm size. It has implication in terms of crop management, protection, harvesting and marketing of the produce. Timely denotification and zoning will help to some extent in curbing this tendency. However, risk in cotton cultivation has to be addressed only through voluntary and community than legislative actions in our system. Varietal proliferation starts with large holdings, where hybrid cultivation is a management alternative for labour shortage with no capital constraints.

Small and marginal farmers with poor soil and abundant family labour when tend to follow the trend encountered frequent crop losses.

Spacing and plant density: The results of the yield gap model fitted independently for hybrids and varieties showed that plant density gap co-efficient was negative and significant for varieties and the soil dummy co-efficient was significant for hybrids. This revealed that the square planting recommended for hybrids on being adopted for variety for operational convenience has resulted in less than optimum population and hence a limiting factor in realising better yields. Also, the hybrids' performance is less than satisfactory when the appropriate conditions like good soil, proper management and care are not obtaining in farmers' fields. Gill et al.(1983) reported that plant density followed by pest control and weed control as the biggest contributor to yield gap, represented by the difference between the recommended method (using suitable stand density, weed management and pest control with a yield of 1910 kg/ha) and the actual production practices (802 kg).

In central India, cultivation of varieties on time and at recommended spacing, will perform better and offer stable income under adverse conditions of shallow soil and scanty rainfall, than risking hybrid cultivation at prohibitive cost for uncertain returns. Optimum population could not be maintained as anything other than square geometry does not find favour with the farmers, as such a geometry does not allow cross-wise ploughing during interculture. For the same reason, intercropping as a technology, though has been proved to be beneficial, has not been preferred by many. Only persuasion through extension will mitigate this trend. On the research front, shallow soil specific, short duration hybrids may have to be developed to meet the demand.

Sub-dued input use: Input use in rainfed cotton is below optimum, especially in case of hybrids, maily because of the risk associated with the investment under frequently failing crop environment. The average N: P: K use was only 80:22:22 kg/ha for the Maharashtra samples. An yield gap function was fitted with the gaps in farm and the potential yields regressed against nutrient gaps, plant density gap and soil dummy as explanatory variables. It was found that potash gap was highly significant and phosphorous gap was significant in both hybrids and varieties, and nitrogen gap was significant only in hybrids, indicating the under application of the inputs and their addition may bring down the yield gap considerably. In case of A.P sample, though the average use was higher, there was a marked decline in farm level P and K consumption over five and ten years period due to phasing out of subsidy to DAP and MOP.

Constraints in plant protection: Plant protection is the weakest link in the production process, where extension could not make a dent in the producer-dealer nexus through tied up credit, with the later having an edge in advocating the time, dose and type of chemicals to be used. Concerted community action has to be called for promoting integrated pest management, on the lines of some South-east Asian countries pre-dominated with smaller holdings and have succeeded in this front. The trend evident in case of pesticides use was - more the risk, more was the number of sprays (Kishore, 1997). More than 30% of the sprays was Monochrotophos, used for its growth promoting effect than as a pest control measure. Tied up credit in case of pesticides was noticed in more than 80% of the cases, has a bearing on the type and dose of chemicals used in the plant protection. Among the technologies overadopted (overadoption is with reference to time than quantity dimension when the recommending authority has ceased recommend the

technology/practice but still the farmer continues to practise) in cotton, repeated use of chemicals (especially pyrethroids), mixing up (cocktailing) of chemicals before spraying, continued cultivation of denotified varieties/hybrids and more flushes are quite common. Seventy two percent cases of overadoption of pyrethroids in rice fallow cotton, was due to unawareness and the rest due to tied up credit that they had to buy and use only the chemical available with the dealer. Unawareness and compatibility, each accounted for forty per cent of tank mixing of chemicals and 20 percent was due to tied up credit. One fall out of tied-up credit, is the forced use of spurious nature of seeds and chemicals that undo the productivity gains.

Constraints in IPM adoption: Despite sufficient awareness, the practice of IPM was not noticed in the entire sample and some have tried and discontinued and felt that it has to be a community venture than an individual initiative. The major lacunae is the lack of simplicity, availability and standardisation of bioagents and scouting skill, which are all prerequisites for successful integrated pest management.

Table 5. Nature and extent of field constraints for rainfed cotton productivity

S. No	Nature of constraints	Maharashtra	Andhra Pradesh	Madhya Pradesh
1	% of farm cotton area to total area	72	55	31
2	% hybrid area to farm cotton area	45	50	88
3	% of farms using certified seeds	35	45	55
4	% of farms using F2 seeds	20	11	5
5	Varietal multiplicity:			
	% of one variety farms	14	13	20
	% of two variety farms	22	21	65
	% of three variety farms	34	38	15
	% of four variety farms and above	30	28	0
6	>70% of the crop area of the sample farms under the varietal combination	NHH – 44, PKVH$_Y$ -1, LRA. 5166	MECH -13, RCH -1, NHH -44, LRA.5166	JKH$_Y$-1, H8/H6
7	Extent of crop area under shallow soil (%)	>50	>20	>10
8	% of farms reporting less than optimum plant density hybrids varieties	Same Less	Same Less	Same Less
9	% of farms practicing intercrop technology	Nil	Nil	Nil
10	% of farms with zero chemical input (‘natural farming’)	20	10	Nil
11	% of farms applying basal dose for cotton	Nil	20	Nil
12	Average N:P:K (kg/ha) applied a. Current b. 10 years before	 80:22:22 65:20:20	 85:30:30 80:40:25	 72:64:18 22:15:15
13	% of farms using less than recommended	70	55	70

	dose of fertilizers			
14	% of farms practicing IPM	Nil	Nil	Nil
15	% of farms resorting to more than recommended number of sprays Number of sprays given % of monocrotophos to total quantity of pesticides used	10-12 >30	14-16 >40	6-8 >30
16	% of farms showing institutional credit shyness	55	>70	52
17	Average no. of pickings	>15	10-12	6-8
18	% of farms following grading	Nil	Nil	Nil
19	Yield (q/ha)			
	Hybrid	4.8	6.5	6.3
	CV (%)	55	60	35
	Variety	4.0	5.8	5.0
	CV (%)	20	25	10

Source: P.Ramasundaram and H.L.Gajbhiye, CICR, Annual Reports (1995-1999)

Institutional credit shyness: While we cannot help phasing out subsidies in an era of market economy, liberal, cheap and timely credit has to be ensured. Otherwise credit tie-ups with unscrupulous vendors will continue, which has resulted in indiscriminate use of pesticides as most of the times plant protection control measures are decided by the dealers having stake to push off their stock. The extent of credit tie-up was more than 70 per cent in case of A.P. sample. For sustainable cotton production, full financing of cotton production and processing is more important than subsidies. Quality control of inputs through liberal institutional credit will have desirable influence on yield, than adding new technologies.

Constraints in scientific picking and grading: Under rainfed situation the number of pickings as was found in the aforesaid survey was determined by the need for cash, threat perception, lack of pressure for vacation of land for second crop, incidence of rains or the availability of protective irrigation leading to second flush even. In this process there anjnstances of picking taking place even more than fifteen times whereas the best of the produce would have been over in second picking. This has implication from quality point of view, besides bringing down the average price fetched, especially when grading by varieties and time of picking at farm level was almost absent. Overadoption in the second flush in rice fallow cotton was due to its good performance and further economic benefits unmindful of the possible pest build up.

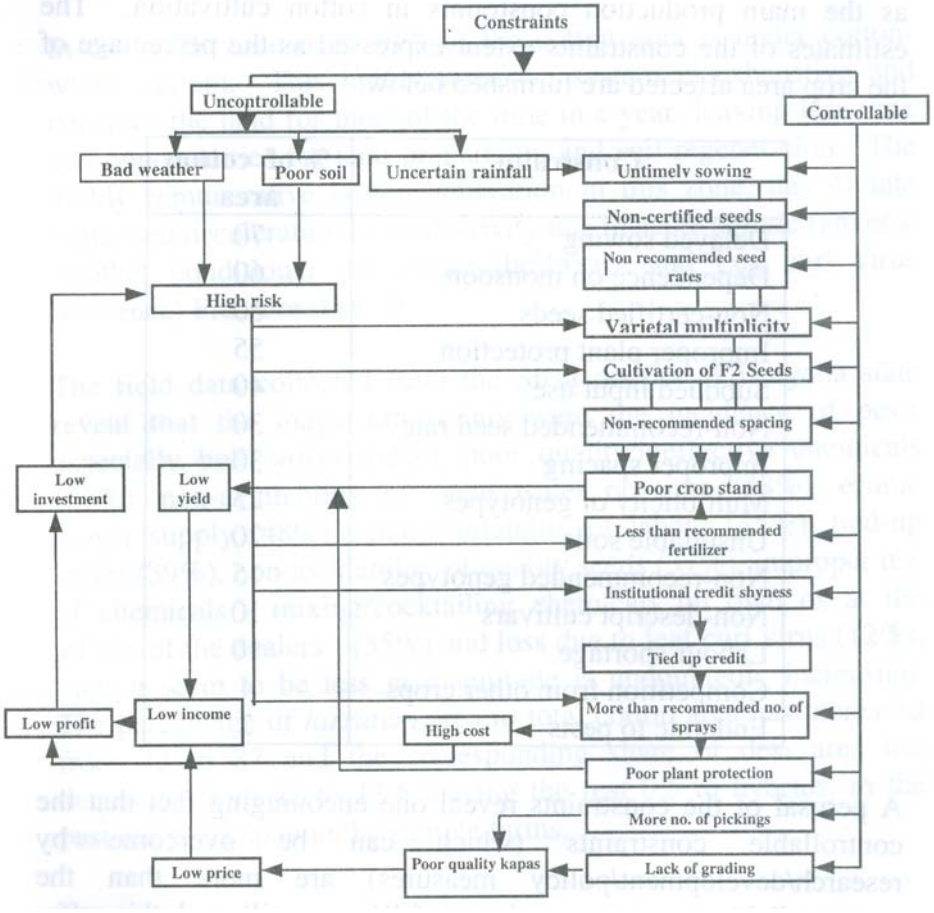
Marketing constraints: Maharashtra has unique scheme of monopoly procurement, processing and marketing of raw cotton in operation for more than twenty five years. Still the scheme has suffered severe losses on account of illegal inter state movement of cotton over years. During the study years it was found that cotton market arrival was several times the production potential of the Adilabad district. The gap explained the interstate movement, legally banned. Discussions with officials, traders and farmers revealed three major reasons for this diversion - price difference, cash payment and avoidance of credit recovery. Ironically, a model fitted to study the cotton diversion showed that, delay in payment than price as the major motivator for siphoning of the produce despite the prices offered by the state during the study year was one of the highest

in the country.

Data collected from the interior villages of the Dhar district revealed that the small and marginal farmers had to pay 10-20% higher for the inputs they purchased, while they had to dispose of their produce at a discount to the traders. Lack of access to the factor and product market was the major reason for this anamoly.

The information collected from more than 320 farms of the five rainfed districts were used to workout the mechanism of low productivity in rainfed cotton. The framework of the mechanism is as shown in the Fig 1. The vicious circle of low productivity-low yield-low income-low profit-low investment-low productivity has to be dented at weak links in the chain by institutional interventions to boost the cotton yield in rainfed situations.

Fig 1: Mechanism of Low Productivity in Rainfed Cotton



Macro level constraints

National: An attempt was made to document the macro level constraints (incidental due to nature/state/community action/inaction like weather, soil, pesticide use, IPM practice, etc.) to realisation of better average yields and the approximate crop area under each of the major

constraints through expert opinion. The constraint analysis revealed that undependable monsoon, unsuitable soil, varietal multiplicity, use of non-certified seeds, improper spacing, non-descript varieties, inability to take up timely sowing, non-adoption of recommended technologies especially in case of plant protection and fertilizer use, tied-up credit with dealers, non-availability of liberal and cheap institutional credit as the main production constraints in cotton cultivation. The estimates of the constraints extent expressed as the percentage of the crop area affected are furnished below:

Constraint	% of cotton area
Delayed sowing	70
Dependence on monsoon	60
Non-certified seeds	60
Improper plant protection	55
Subdued input use	40
Non-recommended seed rate	30
Improper spacing	30
Multiplicity of genotypes	25
Unsuitable soils	20
Non-recommended genotypes	15
Non-descript cultivars	10
Labour shortage	10
Competition from other crops	4
Endemic to pests	2

A perusal of the constraints reveal one encouraging fact that the controllable constraints (which can be overcome by research/development/policy measures) are more than the uncontrollable ones (uncertain rainfall/poor soil) and this offer scope for relaxation of the constraints through further research, development and extension efforts. In the long run additional welfare gains can be assured, if research resources are used to strengthen our comparative advantage in the future. While the uncontrollable constraints are few and can be brought under the ambit of suitable insurance programme, the controllable constraints are many and man made and are quiet relaxable with effective policy interventions, proactive community approach and even by individual initiative.

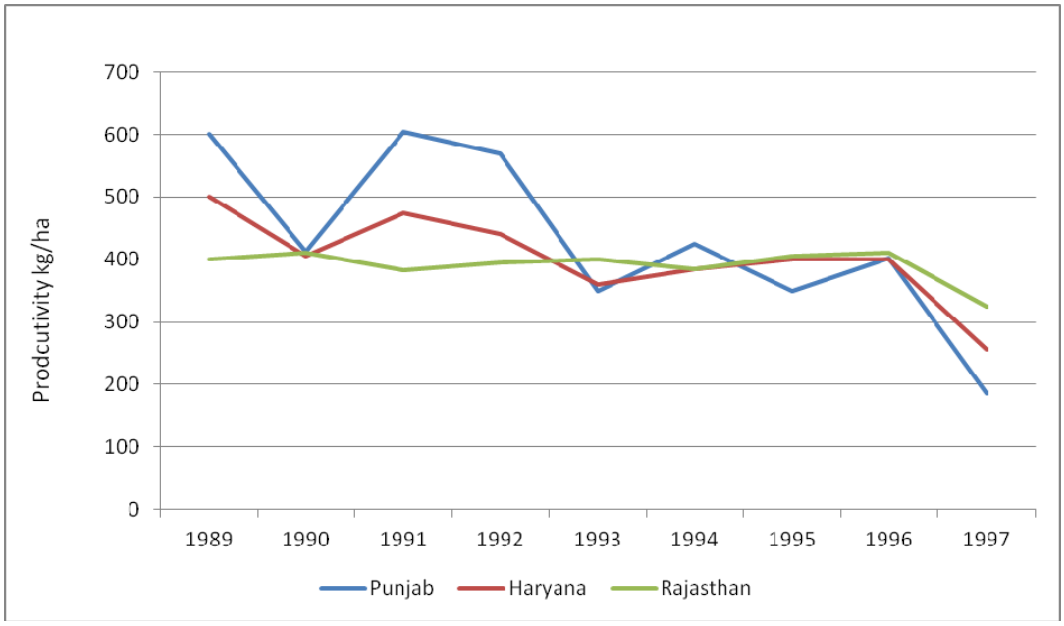
Zonewise constraints and relaxation measures

North zone

In the north zone over 90% of the cotton area is under cotton-wheat system. This highly intensive system is exhaustive and occupies the land for most of the time in a year, leaving less time and opportunities for land preparation and soil regeneration. The highly remunerative cotton cultivation in this zone, has of late witnessed deceleration in productivity due to acute abiotic (adverse weather conditions) and biotic (bollworm and Leg curl virus incidence) Pressure (Fig. 2)

The field data collected from the Sirsa district of Haryana state reveal that the major constraints were the incidence of pests especially boll worm (62%), poor quality/ineffective chemicals (51 %), non-availability of canal water on time (48%), erratic power supply (48%), non-availability of labour (45%), tied-up credit (39%), non-availability of quality seeds (37%), improper use of chemicals - mixing/cocktailing chemicals on own or at the advice of the dealers - (35%) and loss due to leaf curl virus (12%), though seem to be less in magnitude is undoubtedly increasing. The percentage of *hirsutum* area to total cotton area has increased from 72 to 87 and the corresponding share of desi area has decreased from 28 to 12.5 leaving the rest 0.5 to hybrids, in the past ten years span in the sample farms.

Fig.: 2: Declining Productivity of Irrigation Cotton



Constraints

1. Non-availability of canal water on time leading to delay In field preparation, poor germination and poor plant stand.
2. Soils have become saline, crust prone and the germination of cotton is further hampered by high soil temperature in April-May.
3. High cotton yields and cropping intensity result in heavy nutrient exhaustion and development of secondary (sulphur) and micro nutrient deficiency.
4. Removal of farm residues due to paucity of labour and lack of suitable farm implements for land shaping etc.
5. Rank vegetative growth heightened by the ambient soil, water and climatic factors adversely affecting yield realization.
6. Sudden wilt due to physiological reasons during, September October resulting in forced boll opening and sub optimal yields.
7. Non-availability of short duration, early and synchronous maturing varieties to realise complete cotton harvest and timely sowing of succeeding wheat crop.
8. Excessive reliance on pesticides alone for protection of cotton crop has caused several agro-

ecological imbalances.Indiscriminate insecticide spraying, under the guidance of input dealers, who offer credit service but do not have adequate knowledge base for suitable technical intervention to target these toxicants against appropriate life stages of various pests.

9. Weed infestation due to poor plant stand and continuous rains.
10. Leaf Curl Virus disease in the popular *G. hirsutum* cultivars.

Approaches

1. Development of short duration, compact plant types with high harvest index resistant/tolerant to biotic and abiotic stress and amenable for mechanical picking.
2. Partial mechanisation that can complement the labour efficiency; development of mechanical picker in view of the shortage of manual labour and due to the high cost involved in manual picking.
3. Crop residue management and their cost effective utilization.
4. Integrated nutrient management with emphasis on organic sources, biofertilisers including VAM and PSM to improve soil health and sustain soil productivity.
5. Release of canal water to ensure timely field preparation and sowing of cotton has to be ensured to avoid poor plant stand which is the basic reason for less cotton yield in this zone.
6. Injudicious use of natural resource (land, water and applied inputs to sustain the production level), maintain soil health and ecological balance of the cropping system.
7. Reduction in desi area and increase in loss due to leaf curl virus may have to be taken note of till totally immune *hirsutum* lines to the disease are introduced.

Central zone

The central zone is characterised by hot semi-arid climate with mostly shallow to medium and deep black soils. This zone comprises more dry land cotton (93% in Maharashtra, 66% in Gujarat and about 60% in Madhya Pradesh). The yield potentials in dry land are poor, ranging from 300-1000 Kg/ha. Added to scanty and ill-distributed monsoon in Maharashtra and Madhya Pradesh cotton growing regions, there are vast tracts of shallow black soils *(Murrams)* with poor fertility status and moisture retaining capacity. The soils suffer from both impeded drainage, water logging and run-off problems resulting in soil erosion during heavy downpour and moisture stress under drought. Hence, soil as well as moisture conservation measures are required as waterlogging, run-off and erosion due to heavy rains occur during the vegetative phase and moisture stress in witnessed during the reproductive phase. In parts of Gujarat, sandy coastal alluviums, saline, alkaline soils and desert sands are put under cotton cultivation.

Constraints

1. Abundance of resource poor farmers whose cotton cultivation is dependent on the vagaries of monsoon. The unpredictability of rainfall and high element of risk leads to low input usage.
2. Cotton is mainly grown on shallow and medium deep soils, which have low available water holding capacity and are highly erosion prone.
3. Most of the rainfall is received during July and August in short and heavy spells, resulting in high runoff and soil loss and 4080% of the rain water goes unutilized in the absence of proper soil and water conservation measures.

4. Abiotic adversities like cloudy weather, water logging during initial stages, moisture stress at later stages aggravate physiological shedding of buds and bolls.
5. Jassids and bollworms are the major pests of cotton. Unfavourable weather conditions affect the timely pest control in the early stages of the crop.
6. Infection by powdery mildew and bacterial blight diseases cause premature crop cessation and reduction in yield.
7. Resource poor farmers rely on credit based input service system in the zone and the pest management advisory role is mainly by pesticide dealers who are not qualified for the job.
8. Cotton cultivation on clayey soils requires high draft power but the nature of the soil limits the use of heavy farm machinery. Consequently the operations are mainly done manually. Non availability/high cost of labour is a major constraint.

Approaches

1. Adoption of soil and water conservation measures, micro-level water shed based planning and development would increase crop production and the water table.
2. By recycling of harvested rainwater at peak boll development stage, the productivity of cotton could be increased by 25 to 50 per cent. A single irrigation of four centimetre is recommended at peak boll development stage as the crop usually faces moisture stress at this stage on shallow and medium soils.
3. Micro irrigation systems like drip and sprinkler to improve the water use efficiency of collected rainwater to be popularised.
4. Emphasis should be on the development of cultivars tolerant to drought and biotic stresses.
5. Integrated nutrient management techniques with emphasis on recycling of farm wastes and biofertilisers to stabilize cotton production and sustain the soil resource base.
6. Popularisation of alternate pest management strategies and establishment of mass production centres of bioagents should be undertaken.
7. Popularisation of desi *(arboreum)* varieties having superior fibre properties with inherent stress tolerance requiring low levels of inputs would help in mitigating the above constraints.
8. At policy level action can be initiated on promoting one variety communities, seed villages, zoning, community plant protection and protective irrigation, to cite a few.

South zone

In this zone, cotton is grown in about 18.8 lakh hectares, 87% of which is in Andhra Pradesh and Karnataka and the rest in Tamil Nadu. There are three cotton growing seasons in this zone – July-September to December-February, October-November to March-April and January-February to June-July. Soils are vertisols, alfisols and entisols and the rainfall ranges from 500-800 mm through kharif and winter. Cotton is also cultivated on rice fallows in Tamil Nadu. In South zone, constraints are state specific with proliferation of varieties, overuse of chemicals, recurrence of cyclone attacks in coastal districts, high cost of cultivation non-availability of genotypes to fit into rice-cotton system and excessive and indiscriminate use of pesticides.

Constraints

1. A large number of varieties/hybrids are grown creating problems in the production of adequate quantitites of good quality seeds. The multiple varietial scenario, also complicates the insect pest problems.
2. Regular occurrence of cyclones in October-November in the coastal AP belt resulting in adverse abiotic stress.
3. Excessive use of nitrogen fertilizers leading to heavy pest incidence in certain pockets.
4. Acute labour shortage in certain productive irrigated areas.
5. Soils are sandy loams, with low water holding capacity, thus inadequacy of stored moisture profile results in poor yields of rainfed cotton.
6. Excessive and indiscriminate use of pesticides has resulted in the development of a high level of resistance to insecticides by pests, leading to resurgence, increased expenditure, low productivity and frequent crop loss.
7. Non-availability of suitable cultivars for rice fallows in coastal Andhra Pradesh.
8. Leaf reddening.

Approaches

1. Popularisation of integrated pest management strategies.
2. Delineation of areas for the cultivation of specific varieties and hybrids and restricting the number of varieties grown in a region.
3. Development of varieties suitable for double cropping system on rice fallows
4. Soil moisture conservation measures particularly for rainfed regions of Karnataka.
5. Development of suitable chemical weed management technology and selective mechanisation for irrigated high productive areas.
6. Site specific productive and compatible intercropping systems, particularly in irrigated areas.

Comprehensively, the state level constraints identified and the needed plans of action to remedy the same are consolidated and enlisted in Table 5.

Table 5.Statewise constraints *vis-a-vis* action plan for cotton production

S. No	State	Constraints	Action Plan
1	PUNJAB & HARYANA	i) Delayed sowing due to closure of canals for maintenance during sowing time: if the optimum sowing period of April last week or May first week is not adhered to, an yield loss of 1/5 to 1/3 rd of normal yield results	Better coordination between agriculture and irrigation departments: use of ground water through tube wells to take up timely sowing
		ii) Low plant population	Ensure optimal seed rate (25kg/ha) and plant density

		iii) Soil encrustation	Seeds of pulses or green manure crops sown with cotton will ensure better germination and later they can be thinned.
		iv) Use of low viability seeds	Promotion of seed villages: Production and distribution of certified seeds
		iii) Cotton leaf curl virus incidence	Maintaining a buffer of arboretum zone across the international border: cultivation of tolerant or resistant cultivars of G. hirsutum following the buffer: development of immune line against CLCV.
		iii) Excess water and rank vegetative growth	Shift to ridges and furrow method in lieu of bed method will lead to better water management and high productivity. Also irrigation to alternate rows.
		iv) More desi cotton area (20-25%) in Haryana	Substitution with American cotton will improve the state average yields.
		v) Competing crop sunflower	Stabilize cotton price.
		vi) Labour shortage during harvest	Introduction of partial mechanisation.
2	RAJASTHAN	i) Non – adherence to sowing time due to canal closure	Better coordination between agriculture and irrigation departments to ensure water supply during cotton sowing.
		ii) Low use of fertilizers: less content of native phosphorus	Land stabilization development works should be carried out as the new command area are mostly sandy and less fertile, followed by split application of nitrogenous fertilizers.
		iii) Leaf curl virus	Vector control, cultivation of arboretum genotypes in the affected places and along the international border as a buffer and development of resistant genotypes.
		iv) Poor population due to high temperature	Development of thermo insensitive varieties.
3	MAHARASHTRA	i) Shallow soils constitute 1/3rd cotton area	Evolving (Desi hybrids) genotypes and technologies suited to shallow soils.
		ii) Non-availability of certified seeds and prohibitive prices of hybrids	Promoting community seed villages: exploitation of CMS and GMS mechanisms to reduce the cost of hybrids: compulsory certification.
		iii) Delayed sowing	Community borewells for irrigation may facilitate advance and dry sowing.
		iv) Poor productivity, as 98% cotton area is rainfed	Regulation of soil moisture-drainage during excess and conservation during stress. Earthing up after heavy monsoon and tieing up the ridges will prevent run-off and facilitate percolation.
		v) Early withdrawl of monsoon leads to 45-50% yield reduction	On farm community basis water storage will ensure 2-3 wettings in post monsoon period. Use of micro irrigation – drip in hybrids and sprinkler in varieties.
		v) Proliferation of genotypes (nearly 50), & difficulty in purity maintenance, plant protection and grading	Effective enforcement of cotton control order, denotification of outdated genotypes, varietal zoning and premium on one variety communities.
		vi) Low level management and subdued use of inputs	Compulsory crop insurance delinked from credit
		vii) Square planting of varieties and less plant population	Modification of 'dattari'(marker) to suit cross wise interculature.

4	MDDHYA PRADESH	i) Poor quality seeds, more dependency on rainfall and low management	As for Maharashtra
		ii) Competing crop-Soybean	Stabilize cotton price and yield
5	GUJARAT	i) Continuous crop of cotton in certain pockets leading to heavy pest buildup	Crop rotation
		ii) Wider spacing in rainfed cotton	Persuasion through extension / intercropping of suitable oilseed / pulse crops.
		iii) Competing crop – Groundnut	Stabilize cotton price.
6	ANDHRS PRADESH	i) Cyclone damage in major cotton areas – Guntur and Prakasam districts	Decelopment of genotypes with resistance to water logging
		ii) Continuous cotton cropping in Guntur-leading to heavy pest buildup.	Crop rotation: crop holidays in severely affected 'hot spots'.
		iii) Excessive insecticidal use and resistance development in insects	Institutional intervention to overcome tied-up credit: development and practice of IPM
		iv) Non-availability of certified seeds	Strengthen seed production and distribution.
		v) Varietal proliferation	Monitoring, denotification and enforcement
		vi) Problem in promotion of rice fallow cotton	Evolving short duration cotton genotypes
7	KARNATAKA	i) Poor retention of soil moisture	Earthing up and cross tieing of ridges
8	TAMIL NADU	i) Problems in area expansion	Rehabilitating winter Combodia tract; Extending area under summer cotton in coastal districts; Introduction of short duration rice fallow or crop rotation in single crop of paddy land.
		ii) Deterioration in the quality of MCU 5 and Suvin	Maintenance breeding to ensure gentic purity of parental lines.
		iii) Endemic *Verticilium* wilt menace	Development of varieties tolerant/resistant to the disease

Suggestions for national approach

To sustain the pre-eminent position of cotton in the country's economy and enhance profitability of cotton cultivation, total revamping on the policy front is required to meet the ensuing competition where price, phytosanitary standards, honouring the commitment, timely delivery and quick adjustment to the changing economic order are going to be the chief determinants of a country's standing in the international commodity trade. In relaxing the constraints and enhancing the cotton yield, suggested and identified remedies at research, development and institutional levels are:

- ⇨ Popularisation of seed villages, varietal zomng and agropharmacy concepts.
- ⇨ Prevention of proliferation of genotypes and making available quality seeds.
- ⇨ Delineation of areas for different cotton species, varieties and hybrids for higher productivity.
- ⇨ Evolving shallow soil specific genotypes and production technologies.
- ⇨ Micro irrigation has to be introduced through cheaper institutional credit.
- ⇨ Community wells for irrigation supplemented by seed villages atleast in case of varieties, will provide cheap and quality seed supply in the proximity with one variety villages.

- ⇨ Provision of community bore wells for irrigation wherever watershed development is not possible.
- ⇨ Developing and adopting appropriate soil and water conservation measures in central zone and cropping system based fertilizer/integrated management.
- ⇨ Mass campaigning of IPM through Biological control/Bio-labs at district level.
- ⇨ Compulsory comprehensive insurance delinked from credit (in selected cotton districts).
- ⇨ Organising integrated cotton production and processing cooperatives for value addition at farm level.
- ⇨ Restructuring pesticide delivery system/district pesticide inventory scheduling and introducing agro-pharmacy.
- ⇨ Waste lands in vastness, can be let in long term lease for 'corporate farming' for individual mills or federation/association so that one variety uniform quality lint can be produced in larger tracts where individual farmers can not venture.

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