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HDPS in COTTON

Q&A

High Density Planting System in Cotton : Question & Answer

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ICAR-CENTRAL INSTITUTE FOR COTTON RESEARCH, NAGPUR

HDPS

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PREFACE

The productivity of Indian cotton is 445 kg lint/ha which is far below the global cotton productivity of 775 kg lint/ha. About, 63 percent of the cotton area is rainfed. Majority of the rainfed area is in the central and southern zones. Most of the rainfed area has soils that are shallow to medium depth, have low water holding capacity, are poor in fertility and undulating in topography. These factors limit growth of the popular hybrids and consequently the yield is low. As a result, cotton grown in 37% of the country's area produce less than 300 kg lint/ha. It is necessary to overcome on challenges in these areas to increase cotton yield and improve livelihood of the farmers. One scalable technology for such situations is High Density Planting System (HDPS) through short season, compact genotypes dovetailed with appropriate agronomy (spacing, nutrient scheduling and canopy management).

In India, HDPS is ideally suited to rainfed situation than irrigated. Critical to the success of HDPS is availability of early maturing compact cultivars (<150 d) with synchronous flowering/boll bursting habit and amenable for mechanical harvesting. The aim of HDPS is to enhance productivity per unit area rather than on per plant basis by targeting amenable cultivars to soil type with appropriate crop geometry. ICAR-CICR conceptualized this system in 2009-10 and in coordination with the AICRP on Cotton network evaluated more than 60 genotypes and identified the most appropriate genotypes and spacing for different locations. More than 5000 demonstrations were undertaken between 2012-13 and 2016-17 with financial aid from NFSM with the participation of SAUs, State governments, KVKs in 30 districts of 11 cotton growing states – Punjab, Haryana, Gujarat, Rajasthan, Madhya Pradesh, Maharashtra, Telangana, Odisha, Karnataka, Andhra Pradesh and Tamil Nadu under varying soil and climatic regimes. A complete production technology was also developed under a project in the Technology Mission on Cotton funded by ICAR. A spin-off of HDPS technology was a change in the agenda of cotton breeders of both public and private sector to focus on early maturing, compact plant types suitable for HDPS with emphasis on more bolls per unit area than robust plants with more bolls per plant.

About 38 lakh ha in 20 districts across states of Maharashtra, Telangana and Madhya Pradesh where the current cotton productivity is less than 300 kg lint/ha. Cotton is predominantly cultivated under rainfed conditions in these districts where shallow to medium deep soils are predominant. HDPS is perhaps the most appropriate technology to target such areas for productivity enhancement.

Under the Special Project on Cotton funded by the Department of Agriculture and Farmers Welfare (DA & FW), GoI, large scale demonstrations of HDPS are being implemented in farmers' fields in PPP mode by ICAR-CICR in collaboration with seed and textile industry associations, ATARI-KVKs and State Departments of Agriculture. It is our hope that this publication styled as Q & A will be a useful ready reckoner for extension functionaries, implementing partners, KVKs, end users and all stakeholders interested in enhancing cotton productivity in the country

Director
ICAR - CICR, Nagpur.

What is the importance of cotton production and consumption in the Indian economy?

Cotton is one of the most important commercial crops cultivated in India. India produces around 25% of the total global cotton production. Cotton plays a major role in sustaining the livelihood of an estimated 6 million cotton farmers and another 40-50 million workforce engaged in related activities such as cotton processing and trade. The ratio of use of cotton to non - cotton fibres in India is around 60:40 whereas it is 30:70 in the rest of the world. India is the 2nd largest consumer of cotton in the world with estimated consumption of 311 lakh bales. Cotton is one of the largest contributors to India' net foreign exchange by way of exports in the form of raw cotton, intermediate products such as yarn and fabrics to finished products in the form of garments etc. Besides lint, India also produces about 1.2 million tonne cotton seed oil every year as a co-product. Due to its economic importance, cotton is also termed as "White Gold".

The details of production and consumption of cotton during the last 5 years is given below:-

Year	Production (lakh bales)	Consumption (including Mill, SSI and Non Textile)(lakh bales)
2018-19	333.00	311.21
2019-20	365.00	269.19
2020-21	352.48	334.87
2021-22	311.17	322.41
2022-23*Provisional	343.47	311

* - As estimated by Committee on Cotton Production and Consumption (COCPC) in its meeting held on 01.06.2023

How many cotton species are grown in India and which is the dominant one?

India grows all the 4 cultivated species of cotton *viz., Gossypium hirsutum, Gossypium herbaceum, Gossypium barbadense* and *Gossypium arboreum. G. hirsutum* is the dominant species of cotton grown in India and across the globe. Majority of the BG II hybrids grown today are intra-hirsutum type (cross involving 2 *G. hirsutum* parents).

Which are the regions producing cotton?

Owing to geographic proximity and convenience the cotton growing areas have been divided into three zones- North, Central, South zones.
North Zone :Punjab, Haryana, Rajasthan
Central Zone: Gujarat, Maharashtra, Madhya Pradesh and Odisha
South Zone: Telangana, Andhra Pradesh, Karnataka, Tamil Nadu

What is the extent of area and production of cotton in the country and in the world?

During 2021-22, the global area under cotton cultivation was 32.31 million ha and India accounted for 12.15 million ha (37.6%) while the cotton production at global level was 25.14 million tonnes of which India' cotton production was 5.33 million tonnes.

In how many states cotton is grown in the country?

In India cotton is grown in 11 states across three cotton growing zones. Cotton is also grown in isolated patches in the north eastern region.

S No.	STATE	Area (lakh Hectares)	Production (lakh bales of 170 kgs. each)
		2022 -23 (P)*	2022-23 (P)*
1.	PUNJAB	2.49	4.60
2.	HARYANA	5.75	10.00
3.	RAJASTHAN	8.15	27.74
	NORTH ZONE TOTAL	***16.39***	***42.34***
4.	GUJARAT	25.54	94.97
5.	MAHARASHTRA	42.29	84.09
6.	MADHYA PRADESH	5.95	17.22
	CENTRAL ZONE TOTAL	***73.78***	***196.28***
7.	TELANGANA	20.25	53.13
8.	ANDHRA PRADESH	6.99	15.79
9.	KARANATAKA	9.23	25.41
10.	TAMIL NADU	1.62	3.56
	SOUTH ZONE TOTAL	***38.09***	***97.89***
11.	Odisha	2.16	6.65
	Others	0.19	0.31
	All India	***130.61***	***343.47***

* - As estimated by Committee on Cotton Production and Consumption (COCPC) in its meeting held on 01.06.2023

What are the types of farming situations under which cotton is cultivated and what is their share?

Cotton is grown under irrigated and rainfed farming situations. Under irrigated conditions, cotton-wheat and cotton-paddy are the common double cropping systems. About 33% of the cotton area in the country is irrigated. About 67% of the cotton area is rainfed and this system is predominant in the semi-arid regions. Under rainfed situations, cotton is either raised as a sole crop or it is often strip inter-cropped with pigeon pea.

Which soils are ideally suitable for growing cotton?

Cotton is grown on a variety of soils ranging from deep black clayey soils of varying depth to sandy soils, red soils and alluvial soils. Cotton is semi-tolerant to salinity and sensitive to water logging and thus prefers well drained soils. Ideal cotton growing soil should be deep, loose and friable to facilitate uniform germination, quick early crop establishment and extensive root growth.

Cotton grows best on neutral to slightly alkaline soils and a pH of 6.5 to 8.0 is considered optimum. Cotton can be grown on a range of slopes, but flat to gently sloping terrain is ideal.

In areas with assured rainfall, medium deep soils with good internal drainage can support a good rainfed cotton crop. In areas with <800 mm rainfall, deep or very deep, moderately well drained soil supports good rainfed cotton.

How has the cotton area expanded after the Bt cotton introduction?

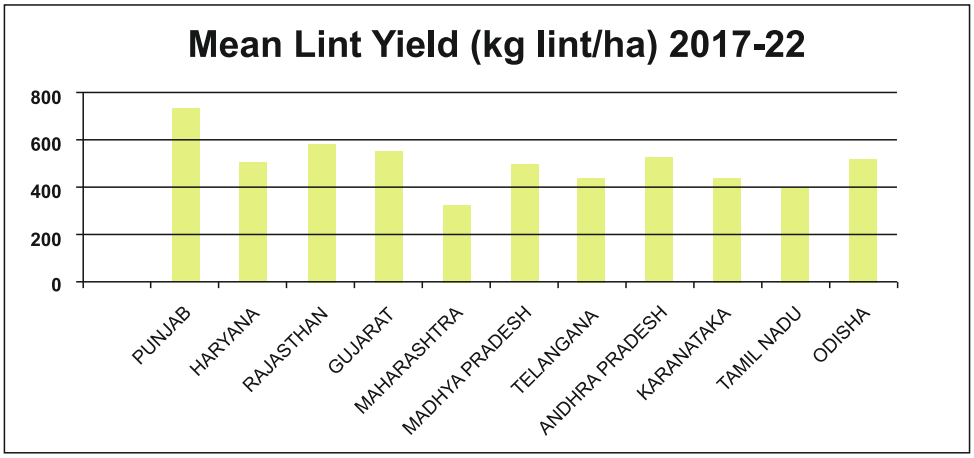
Bt cotton was introduced into India in 2002-03. The area under cotton increased from 76.67 lakh ha in 2002-03 to 134.71 lakh ha in 2019-20 and is presently around 130 lakh ha. A part of the additional area occurrs on soils not ideally suited for cotton.

What is the productivity level of cotton in India?

The mean productivity level of cotton during the last 5 years ending 2021-22 is 433 kg lint /ha.

How does the productivity of cotton vary across the different states?

The five year mean (2017-18 to 2021-22) productivity of cotton in different states is depicted in Figure below. The productivity ranges from 322 kg lint/ha in Maharashtra to 731 kg lint/ha in Punjab.



Within the state the productivity is higher in areas where irrigated cotton is grown and where cotton is grown on soils suitable for its growth.

Q11 What is the productivity level in major cotton growing countries?

The productivity of cotton in some major cotton growing countries is given in the table below.

	Productivity in kg lint /ha			
Country	**2019-20**	**2020-21**	**2021-22**	Mean
United States	931	950	987	956
Brazil	1802	1719	1,772	1764
China	1758	1864	1,844	1822
India	464	446	466	459
Turkey	1704	1827	1735	1755
Australia	1657	2047	1226	1643
Pakistan	522	445	467	478
Mexico	1650	1584	1592	1609
Uzbekista n	513	994	994	834
World	758	760	775	764

Source: https://icac.org/DataPortal/DataPortal?Units=Yeild&Year=2021/22%20proj accessed on 23 June, 2023

Q12 What are productivity factors of India vis-a-vis other select countries?

Cotton productivity factors vis-à-vis other select countries are compared in the table below-

Parameter	India	China	Australia	Brazil	USA	Pakistan
Cotton area (lakh ha-2020-21)	130.6	31.7	2.97	13.7	33.5	20.0
Farmers (No.)	65 Lakhs	86 lakhs	182	1240	8103	1.8 lakhs
Farm size (ha)	1.2	0.4	450	1339	624	1.4
Irrigated area (%)	33	80	89	4*	32	100
Seed	Bt	IR, HR	IR, HR	IR, HR	IR, HR	IR
Dominant planting method	Dibbling, wide spacing	Planter, HDPS	Planter, HDPS	Planter, HDPS	Planter, HDPS, UNR	Dibbling, Wide Spacing
Crop duration (days)	>180	**160**	150	150	160	170
Productivity (kg lint/ha-mean 2019-20 to 2021-22)	459	1,822	1643	1764	956	478
Cultivation cost /ha (US $/ ha)	600 – 1137	**3510**	2716	2264	1543	855
Production Cost per Kg lint (US $)	1.15	1.57	1.69	1.09	1.35	0.71

*Assured high rainfall in the remaining areas

Q13 Elaborate the global best practices identified for achieving higher productivity in India?

Some Global best practices for the enhancement of productivity of cotton in India are-

- **Deploying cotton varieties/hybrids** with early maturity (140-160 days), compact height (110-120 cm tall), sympodial architecture with synchronous flowering and fruiting, high initial vigour, big boll size, high harvest index (0.35-0.4), resistant to biotic and abiotic stresses, with high GOT(> 40%) and amenable to defoliation and mechanical picking
- **Optimizing plant geometry and planting density**: Increase plant density to

more than 60000 plants/ha for short duration, compact hybrids and more than 1 lakh/ha for early maturing varieties by optimizing row spacing at 0.75m to 1.0 m and within row spacing to 0.1 to 0.2 m depending on the soil fertility, moisture availability, genotype characteristics and growing season.

- **Canopy management:** Growth regulation to balance vegetative and reproductive growth, improve light penetration, increase retention of first position bolls, increase boll size and impart synchronous boll opening. This can be accomplished by manual (de-topping and removal of monopodial branches) methods or through PGRs (mepiquat chloride/clormequat chloride). Choice, application rate and timing of PGRs is determined by the size of the plant, its age and environmental conditions and anticipated weather conditions.
- **Soil nutrient management**: Nutrient status of the soil can be determined by soil testing or sensors and plant analysis. Synchronizing nutrient availability with plant nutrient demand, saves fertilizers, improves nutrient use efficiency, ensures timely cut off and results in high yields.
- **Water management**: Avoid water stress from squaring to the end of flowering window. Adequate soil moisture during this critical phase helps plants establish the desired canopy structure and helps in the retention of fruiting forms. Arid/semi arid dry eco-regions have higher water requirement than the humid regions and micro-irrigation systems can be used to save water and improve water use efficiency. In semi-arid moist and dry sub-humid eco-regions, only supplemental (to rainfall) irrigation is needed. This can be provided in alternate furrows. Cotton is extremely sensitive to excess moisture and water stagnation could reduce yields particularly in heavy textured soils. Hence, drainage is as important as irrigation for cotton crop.
- **Inclusion of legumes in cropping system:** Cotton is either rotated or inter-cropped with legume crops for nitrogen-fixing and breaking disease/pest/nematode cycles. Cultivation of legume intercrops in between rows or in crop rotation reduces the need for repeated weeding and can assist in conservation agriculture.

(a)

(b)

(c)

Cotton based intercropping systems: a) cotton+soybean, b) cotton+cowpea c) cotton+cluster bean

Cotton crop shredding and residue incorporation: Post-harvest shredding and incorporation of cotton stalks into soils plays an important role in pest management and nutrient management. Shredding of stalks prevents over wintering of the pink bollworm. It also ensures a mandatory 90 days host free period for pink bollworm management. A rainfed cotton field yielding 2 tonnes/ha stalk when shred and incorporated can recycle 12.4-20.0 kg N, 1.6-2.0 kg P_2O_5 and 12.2-13.6 kg K_2O/ha and in the long run, improve soil structure, increase organic carbon content and improves the soil water holding capacity

Conservation tillage for soil health management: Conservation tillage/minimum tillage and crop residue management practices enhance soil health with high residue cover, crop residue mulching, minimum tillage, etc. Wherever possible, zero-tillage and strip tillage should be practiced to facilitate timely planting, reduce erosion and

conserve moisture.

Eco-conscious pesticide usage: Reducing early season insecticide applications and careful choice of eco-compatible and biological-control-friendly insecticides can be adopted for highly efficient season-long pest management through conservation of the natural enemies of pests in the cotton ecosystem.

Use of precision tools for crop monitoring and input delivery: Several tools and techniques are now available for monitoring crop growth, quantifying the variability in the cotton field and facilitate site-specific management of inputs. Soil and above ground sensors, GPS, GIS, and remote sensing technologies make the precise seeding of cotton seed, herbicides, pesticides, fertilizers, water and plant growth regulators. Their adoption would not only reduce the cost of production, but would improve yield and also reduce the emission of greenhouse gases. UAVs/drones containing high- resolution sensors and image processing systems are available for crop monitoring. Drones are also available for pesticide delivery.

Pesticide spray using drone

Q14 Give a glimpse of the global best practices contributing to higher productivity of cotton

Global best Practices contributing to higher productivity

Parameter	Best Practice
GM events	IR, IR+HT, HT
Plant architecture	Compact varieties, sympodial branching
Crop duration	Short duration (150 days)
Planting system	High density planting
Canopy management	PGRsto aid early fruiting form retention and manage crop architecture
Cropping systems	Cotton-legume rotation / intercropping for nitrogen fixing
Soil health management	Minimum tillage, crop residue cover, bio-mulching
Input use efficiency	Optimum use of water, manures, fertilizers, pesticides – precision cotton farming
Harvest	Synchronous maturity, use of defoliant/ boll openers for one picking (mechanical)

Q15 Which seed types of cotton are in use in India?

Seeds of both hybrids and varieties are used in India. The non-Bt seeds of varieties belonging to the 4 species viz., *G. hirsutum, G. barbadense, G. arboreum* and *G. herbaceum* as well as Bt seeds of varieties belonging to *G. hirsutum* cotton carrying cry 1 Ac gene are available. Non-Bt hybrid seeds belonging to hirsutum x barbadense and hirsutum x hirsutum and arboreum x arboreum are also available. However the most popular cotton seeds sold in India is the Bollgard II (BG II)(containing the genes Cry 1 Ac and Cry 2 Ab) in hirsutum x hirsutum (intra hirsutum) category. Few BG II hybrids belonging to the hirsutum x barbadense (inter-specific) category are also popular.

Q16 How does a variety and hybrid differ in terms of growth and yield?

Unlike varieties, the development of hybrids utilizes the phenomenon of heterosis or hybrid vigour in which the F_1 (seed that is commercially sold and planted) exhibits superiority in terms of early vigour, growth, dry matter production and yield per plant in comparison to their inbred parental lines. They bear more number of bolls per plant but have a longer fruiting window. The number of pickings is also generally higher than varieties. Hybrids are often input intensive and adapt well to high soil fertility, respond better to fertilizers and irrigation.

Q17 How does a variety and hybrid differ in terms of seed rate and spacing?

To exploit the heterosis or hybrid vigour, hybrids are traditionally planted at wider spacing compared to the varieties. Consequently, the plant population/ha is lower in

hybrids (15-20 thousand/ha) compared to varieties (50-60 thousand/ha). Hybrid seeds are bolder and costlier than varietal seeds. The seed rate of hybrid seed is around 1/3 of that of varieties when planting is done manually.

Do we have suitable compact varieties and hybrids released for commercial cultivation for High Density Planting System (HDPS)?

Cotton is an indeterminate species and unlike determinate plants, the terms compact/semi compact/bushy are relative. The growth pattern of a variety/hybrid is strongly affected by inherent soil conditions, climatic features during the growing period and input (nutrients and water) applied. Nevertheless, recent breeding efforts have led to the development and release of compact and semi-compact varieties and hybrids that can fit into HDPS. Additionally mechanical (monopodia removal, de topping, trimming of sympodia) techniques as well as chemical growth regulators can be used to induce compactness.

Why is the seed rate of cotton low in case of hybrid seed?

The seed rate of hybrids is low for the following reasons-

i. Hybrids are planted at wider spacing in order to exploit the hybrid vigour and consequently the number of plants/ha are low (usually 1/3rd of that of varieties).

ii. Hybrid seed production involves emasculation and pollination and these processes are both labour and cost intensive. The seeds obtained are processed, graded and coated with agro-chemicals.

These practices increase the cost of hybrid seed production and the seed cost is higher for hybrids as compared to varieties. Farmers use hybrid seeds judiciously by planting only 1 seed in dibbles spaced wide apart. Thus the seed rate is low around 500 g/acre if planted at 90 x 90 cm spacing or 1 kg/acre if planted at 90 x 45 cm spacing.

Does row to row and plant to plant spacing vary in different soils/ growing environments?

Yes. In deep, fertile soils and in environments (irrigated/assured rainfall/heavy nutrient application/long growing period) favoring bushy growth, wider spacing of 90-120 cm between rows and 45-60 cm between plants is the spacing adopted for hybrids. On medium deep (50-75 cm depth) soils, closer spacing of 90-120 cm between plants and 30 cm between plants in a row is recommended. On shallow soils (30-50 cm depth), red soils with low water holding capacity, 90 cm between rows and 15-20 cm between plants is now recommended.

Q21 What is per plant productivity vs productivity per unit area? How does it differ with hybrids under wider spacing and in HDPS ?

Seed cotton yield per plant (or productivity per plant) is a product of number of bolls harvested per plant and the weight of individual boll. This product is further multiplied with the plant population per unit area to obtain productivity per unit area (sq m or acre or ha etc). The following table illustrates the difference between hybrids planted at wider spacing and HDPS.

Category	Spacing (cm)	Plant population per acre	Boll no./plant	Boll weight (g)	Productivity per plant (g)	Productivity (Seed cotton q/acre)
Conventional spacing I	90 x 60	7407	30	4.0	120	8.88
	120 x 45	7407	40	4.0	160	11.85
Conventional spacing II	120 x 60	5556	30	4.0	120	6.67
			40	4.0	160	8.89
			50	4.0	200	11.11
HDPS	90 x 15	29630	10	4.0	40	11.85
			12	4.0	48	14.22
			14	4.0	52	15.40
	80 x 20	25000	10	4.0	40	10.00
			12	4.0	48	12.00
			14	4.0	52	13.00

It is evident that compared to conventional spacing, the bolls/plant are fewer under HDPS and hence the yield per plant is low. However, due to a higher plant population per unit area (plant density), the yields at par or higher than that with conventional spacing can be obtained. Moreover the fruiting window (flowering to boll bursting) is longer in conventional spacing (since more bolls have to be set on each plant). This increases the cost of nurturing the crop for a longer period.

Q22 How does the seed rate used at present in India compare with countries using varieties and having higher productivity?

More than 95% of the cotton area in India is sown using BG II hybrids. The seed rate ranges from 1.5 to 2.5 Kg/ha depending on the spacing adopted. In contrast, countries realizing high productivity plant varieties at a higher seed rate. The seed rate is given in table below-

Country	Seed rate kg/ha
Argentina	16-32
Australia	12
Brazil	12-15
China	15-30
Egypt	50
Greece	25
Mexico	10-15
South Africa	15
Turkey	25
USA	12
Uzbekistan	35-50

Source: ICAC Cotton Data Book 2021

What is the plant population per ha in India vs other countries?

In India, BGII hybrid cotton is planted at population densities ranging from 12,346-24,691 plants/ha. This is among the lowest in the world. Other leading cotton growing countries adopt much higher planting densities. (See table below)

Country	Plant population/ha
Argentina	131579-263158
Australia	111000
Brazil	100000-250000
China	111000-222000
Egypt	66667
Greece	173611
Mexico	111111 -133333
Pakistan	44444
South Africa	111111
Turkey	142857
USA	111111
Uzbekistan	111111 -256410

Source: ICAC Cotton Data Book 2021

What is high density planting system?

High density planting system (HDPS) is a technology standardized by ICAR-Central Institute for Cotton Research, Nagpur, India as an alternate cotton production system for realizing high yield. It was initially perfected for varieties aimed at increasing cotton yields at low production costs for marginal growing

environments. It involves planting at high densities and realizing higher yield per unit area and time rather than increasing yield per plant. Under this system, short duration compact/semi compact non- Bt cotton varieties (*G. hirsutum* and *G. arboreum*) were planted at 45-100 cm between rows and 10-15cm between plants. Bt varieties were not available when this technology was developed.

The technology was later extended to Bt varieties (PKV-081 Bt, Rajat Bt, Suraj Bt) and BG II hybrids by planting them at 90cm x 15cm, accommodating 25000-29963 plants/acre. In the current context, where ideal compact plant types are not available, cotton hybrids planted at a population of 25000plants/acre or higher can be considered as high density planting.

Cotton seedlings under HDPS

Q25 Where is HDPS recommended for adoption? Why?

The technology for HDPS is scale neutral and can be adopted at any location provided the right type of geometry is adopted and correct genotype is available. However, our studies have indicated consistently higher returns over the farmers practice under rainfed conditions on shallow (<50 cm) soils with low fertility and red/gravely soils where the length of growing period is <150 days. The response was higher in years experiencing below normal or normal rainfall. In years with excess rainfall or on deep fertile soils, where the crop duration is extended to give multiple picking, the yield gains over conventional planting system were not consistent. Moreover, under deep fertile soil conditions, crop canopy management and crop termination becomes more critical.

Shallow calcareous soil suited for HDPS

Has HDPS technology been tested in India?

The HDPS technology has been extensively evaluated on research farms and in farmers' fields. Extensive on-farm demonstrations using non-Bt varieties were conducted between 2012 and 2016, by ICAR-CICR, State Agricultural Universities (SAUs) and State Dept. of Agriculture. Semi-compact Bt hybrids were initially evaluated in the state of Maharashtra, by private seed companies and by CITI-CDRA in Rajasthan. During the last 4 years under FLD-NFSM Bt varieties developed by the public sector were demonstrated on farmers' fields by SAUs and ICAR-CICR. During the last few years some private seed companies have also conducted extensive demonstration of next generation BG II hybrids bred exclusively for HDPS system in the states of Maharashtra, Telangana, Andhra Pradesh. Non- Bt compact varieties were also demonstrated under HDPS in the summer irrigated rice-fallow conditions of Tamil Nadu recently.

Can HDPS be adopted in *desi* (*G. arboreum*) cotton?

Yes. Under rainfed conditions of Central India, medium staple varieties like CNA 1028 and CNA 1032 and long stapled varieties like PA 810, PA 812 and PA 812 can be planted at 60x15 cm spacing, thus accommodating 44444 plants/acre. De-topping at 90-100 DAS is found useful in *G. arboreum* cotton planted under HDPS.

De-topping in Desi cotton

How is the land to be prepared for HDPS? Is it different from normal sowing?

Land preparation for HDPS is not different from that of the conventional system.

- Do deep ploughing once in 3 years using a mould board plough.
- Add well decomposed FYM (where ever available) @ 2-5 tonnes/acre.
- Spread it and mix it with the soil 2-3 weeks before sowing.
- Perform 2-3 harrowing after the receipt of pre-monsoon showers.
- After the receipt of monsoon rains when the weed seeds just start germinating, harrow the field and level it with a planker to make the field ready for sowing.

Is HDPS practiced only for flat bed sowing? Can it be done on raised beds?

The HDPS technology can be adopted both under flat bed and raised bed land configurations. However, sowing using a pneumatic planter would be less cumbersome on flat beds. On raised beds spaced 90 cm apart, manual planting at 15 or 20 cm spacing along the beds can be done. Few pneumatic planters are also available that can plant the crop at the desired spacing as well as open a furrow at the adjusted row spacing in the same operation. When the crop emerges it gives the appearance of a raised bed and will provide the same benefits of drainage/moisture conservation.

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How much additional seed is required per acre?

At present, the seed rate adopted by farmers cultivating BG II cotton is 1.5-2.0 packets (each of 450 gm) per acre. Under HDPS cotton around 5.5 to 6.0 packets would be needed to plant cotton at 80 x 20 cm or 90 x 15 cm spacing. Thus, 2.5 to 3.5 additional packets/acre would be needed for planting under HDPS.

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What types of machines are required for sowing in HDPS?

Pneumatic as well as inclined plate planter can be used. Pneumatic planters are precise in seed to seed placement, and skips and multiples are significantly reduced, albeit at a higher cost. Inclined plate planters are preferable if budget is a constraint. They do the job fairly well but at a higher seed rate and result in greater skips and multiples.

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How sowing is done in other countries?

Mostly pneumatic planters are used in western cotton growing countries. In Pakistan and China, sowing with inclined plate planters as well as pneumatic planters is done. In the African countries, animal drawn inclined plate planters, seed drills and manual jab planters are in vogue.

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What is Pneumatic planter?

The pneumatic planting concept is based on the suction principle, in which an aspirator is used to develop suction pressure in the metering chamber of the pneumatic disc. A few seeds are held against the orifice hole made on the periphery of seed metering plate due to suction.

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What is the seed rate used in a planter for HDPS?

For planting under HDPS at 90 cm x15 cm spacing using a pneumatic precision planter, a seed rate of 6 packets (of 450g) would be sufficient for planting 1 acre land.

Planting of cotton using pneumatic planter

35 What are the ideal parameters for optimum performance of pneumatic planter?

Fine seed bed preparation and optimum soil moisture are necessary for quick emergence and uniform plant stand in machine (pneumatic planter) planted cotton

For cotton seed planting the parameters for optimum performance of pneumatic planters are; operational speed of the disc, vacuum pressure, diameter of the hole and shape of the entry of seed hole.

The effect of above parameters were evaluated by examining the mean seed spacing, precision in spacing (coefficient of variation), miss index, multiple index, and highest quality of feed index. For picking single seeds, the planter disc had a seed hole of 2·5 mm in diameter. The entry cone angle of the hole was varied from 90 to 150°, the speed varied from 0·29 to 0·69 m/s, and the vacuum pressure from 1 to 2·5 kPa. The metering system of the planter was set to place the seeds at 250 mm spacing. It was observed that the planter disc with a 120° entry cone angle gave superior performance at all speeds and operating pressures. However, there was no conclusive statistical evidence to identify a single value of disc speed or vacuum pressure. Lower miss indices were observed at higher pressures and lower speeds, and lower multiple indices at lower pressure and higher speeds. The metering system with a speed of 0·42 m/s, and a vacuum pressure of 2 kPa produced superior results with a feed index of 94·7% and a coefficient of variation in spacing of 8·6%, recording a mean seed spacing of 251 mm. Optimisation of the regression equations incorporating speed of the disc and operating vacuum pressure through iteration further revealed that a disc, operating at speeds from 0·34 to 0·44 m/s and a vacuum pressure of 2 kPa, yielded similar performance (Singh et al. 2005).

36 What is the time taken to sow one acre using pneumatic planter?

Using a 4 row pneumatic planter at a row to row spacing of 90 cm it will take 45 min to 60 min to plant one acre with cotton.

37 Can HDPS sowing be done by manual methods?

Planting under HDPS can be done manually and indigenous techniques are available. Maintaining the desired plant stand and uniform plant -plant spacing are pre-requisites for realizing high yield under HDPS. Low cost metallic chains resembling Civil Engineering survey chain can be used with slots to denote points to plant. Long ropes with markings at 15/20 cm spacing can be stretched along the row and sowing can be done at the marked points. However, due to continuous use, the nylon rope tends to stretch at the middle and this may increase plant to plant spacing. Alternatively, hollow, narrow plastic pipes can be marked at 15/20 cm length can also be used for maintaining spacing between plants in a row.

(a) plastic pipe

(b) nylon rope

(c) metallic chain

Manual sowing under HDPS using a) plastic pipe, b) nylon rope c) metallic chain

How to do marking of 90 cm rows?

Rows spaced at 90 cm can be made using a marker operated by a pair of bullocks. Tractors can also be used to mark lines at 90 cm spacing.

Marking lines using a bullock drawn marker

How many seeds to be sown per hill?

Under ideal soil moisture conditions**,** only one seed per hill is to be sown if fresh BGII hybrids are used for planting under HDPS. Planting more than one seed would add to the cost of seeds. Additional labour would be required to remove the extra seedlings later.

Is there a need for thinning and gap filling in HDPS?

Since only one seed is sown per hill there is no need of thinning in manually planted cotton. In case of pneumatic planter sown cotton also, only one seed is dropped per spot if the field has been prepared to the desired tilth and hence thinning may not be necessary. If the field conditions are not ideal, there are chances of doubles (seedlings germinated close to one another). If doubles are few they can be retained but if doubles are too frequent, thinning needs to be done. In both manual and machine planted cotton, gap filling is recommended if the gaps are more than 10%.

How much fertilizer is applied in normal sown hybrid cotton crop?

The quantity of fertilizers added to normal BG II hybrid crop differs from region to region. Few representative NPK recommendation currently provided (N: P_2O_5:K_2O in Kg/ha) by State Agricultural Universities is listed herewith.

- Karnataka (UAS Dharwad)- 125:62.5:62.5 for H x H hybrids and 150:75:75 for H x B hybrids
- Andhra Pradesh (ANGRAU, Guntur)- 120:60:60
- Maharashtra (MPKV, Rahuri)- 125:62.5:62.5
- Madhya Pradesh (RVSKVV, Gwalior)- 150:75:40
- Telangana (PJTSAU, Hyderabad)- 120:60:60
- Punjab (PAU, Ludhiana)- 105:30:0
- Gujarat (JAU, Junagarh)- 240:50:150
- Haryana (CCSHAU, Hisar)- 150:60:60
- Tamilnadu- 90:45:45 or 120:60:60
- Maharashtra (VNMKV Nanded)- 120:60:60

How many times fertilizers are applied? At what rates

Nitrogen is recommended to be applied in splits-three equal splits at sowing, squaring and flowering. Entire dose of P can be applied at sowing (except in highly calcareous soils, where P can be split in equal doses and applied at sowing and squaring). K can be applied at one time or in 2 splits at sowing and square initiation.

Is fertilizer requirement higher under HDPS vs normal spacing?

It is advisable to perform soil test before sowing to know the fertilizer requirement. Our studies with non- Bt cotton indicated that the fertilizer requirement under HDPS is 25% higher than the recommended rate for normal spacing of non-Bt varieties. Exclusive studies on fertilizer response of BGII hybrids under HDPS have not been conducted. In general 90:45:45 or 100:50:50 kg/ha (the actual requirement may vary with the location) could be considered as recommended dose and adjustments may be done based on the soil test values. This translates to 36:18:18 kg/acre or 40:20:20 kg/acre.

How to take up weed management in HDPS?

Weed management strategy in HDPS cotton is similar to that of conventional cotton with the exception that cross-wise hoeing is not possible under HDPS. Under HDPS, the canopy closes earlier than in conventional system and this improves competitiveness of the crop against weeds. Weed management schedule under HDPS.

- One hoeing after the receipt of soaking rains before sowing will kill the weeds that are emerging or have just emerged.
- Pre-emergence application of Pendimethalin 38.7% CS@700 ml/acre within 24-48 hr of sowing would prevent weeds for 4 weeks.
- 2 hoeings at a 20-25 and 40-45 days followed by manual removal of left over weeds is recommended.
- If manual / mechanical options are not possible post-emergence herbicide may be applied.

Hoeing using a bullock drawn hoe

45

Which pre-emergence weedicides to use, give rate of application?

Pendimethalin is the most commonly used pre-emergence herbicide for cotton. Pendimethalin 38.7 % CS can be applied @ 700 ml/acre (spray volume 200 lit/acre) within 24-48 hours of sowing. Pre-emergence application of Fluchloralin 45% EC is also recommended @ 0.8-1.04 l/acre.

Pre-emergence application of Pendimethalin

Which post-emergence weedicide to use, give rate of application?

Quizalofop ethyl or Pyrithiobac sodium either alone or in combination are the most commonly used post-emergence herbicides for cotton.

Quizalofop ethyl 5% EC @ 2 ml /lit water is sprayed if the cotton field is infested with grassy weeds, Pyrithiobac sodium 10 % EC @ 1.25 to 1.50 ml/lit water is recommended if the field is dominated by broad leaved weeds. Additionally, Quizalofop ethyl 6% EC @2 ml + Pyrithiobac sodium 4% EC (combination product) @ 2.5 ml /lit of water is recommended to control both grassy and broad-leaved weeds in cotton.

What are the ideal conditions for weedicides use in cotton for optimum performance?

For optimum performance of weedicides, the following aspects must be kept in mind.

- There is adequate soil moisture in the field at the time of pre-emergence herbicide application.
- There should not be any heavy downpour within 6 hours after application of the herbicide
- The application of pre-emergence herbicide should not be delayed beyond 48 hours after sowing. Germination of cotton crop would be adversely affected if the application is delayed.
- Post-emergence herbicides are most effective against younger (less than 10-15 days old) weeds or weed plants of less than 4 inches height. Hence the sprays may be undertaken at the most appropriate time/stage but later than 25 days after sowing.
- A minimum of 200 litres per acre of spray volume should be used for application of both pre and post-emergence herbicides.

How to do interculture in HDPS for weed and soil moisture management?

Due to close spacing between the plants, interculture can be performed only along the rows. Two hoeings can be done using a bullock drawn or tractor operated hoe at 20 and 40 days after sowing (DAS) keeps the field weed free. Earthing up should be done after the third intercultural operation at 50-60 days stage for soil water conservation. The furrow could be closed at 15 m interval to facilitate moisture retention. However if heavy rains are anticipated following the closure of furrows, these may be cut open to facilitate drainage and closed later.

HDPS field after earthing up at 55 days

Q49 When and how to do top dressing of NPK fertilizers in HDPS?

Top dressing should be done at squaring (40-45 days) and flowering stage (70-75 days) in HDPS cotton depending upon the soil moisture and anticipated weather conditions. The desired quantity of fertilizer can be applied by opening a furrow 15 cm away from the main stem using a desi plough. To ensure uniform root growth, the second top dressing may be given by opening the furrow on the opposite side (of the row drawn for the first application).

Q50 Which fertilizer to use at which crop stage, days after sowing and quantity applied?

Straight fertilizers (urea, SSP and Muriate of potash) are the cheapest and best source to apply NPK. SSP also contains S that is needed by the cotton crop. Zincated and boronated SSP can also meet the requirement of Zn and B wherever these elements are deficient in the soil.

Fertilizer schedule	% of recommended dose per Acre
Basal or at time of sowing	1/3rd N, full dose of P* and ½ dose of K
Squaring stage (40-45 days after sowing)	1/3rd N, ½ of K and 5 kg $ZnSO_4$
Flowering and early boll formation stage (70-75 days after sowing)	1/3rd N + 2 kg Borax

* On calcareous soils P may be applied in two equal split doses at sowing and squaring.

Foliar application of nutrients be taken up if soil test report suggests nutrient deficiency (especially of micro-nutrients), in case of excess rainfall received (that would have led to leaching of nutrients) and also to meet the higher nutrient demand by plants when boll load is higher.

Foliar nutrition schedule	Recommended dose per Acre
90-100 days after sowing	Multi-micronutrient (1 kg in 200 litres of water for an acre)
100-110 days after sowing	19:19:19 or 13:00:45 (3-4 kg in 200 litres of water for an acre)

What are plant growth regulators? Need in cotton?

Cotton is an indeterminate plant and hence would continue its vegetative growth by putting forth new branches and also increase in height even after the onset of reproductive phase (squaring, flowering and boll formation). This growth would continue till soil moisture, nutrients or temperature becomes limiting. Under favourable soil fertility and soil moisture conditions, excess vegetative growth would result in intra plant and inter plant competition leading increase in inter-nodal distance and plant height, cause mutual shading of leaves, shedding of squares and fruiting forms. The micro-climate under the canopy of an excessively grown crop becomes conducive to a number of foliar diseases and boll rot disease. All these negatively affect yield, prolong the crop duration, drain out nutrients from soil and add to cost of plant protection.

Plant growth regulators (PGR) are agro-chemicals (hormones) that are applied to control excessive vegetative growth, retain first formed bolls, promote higher yield, improve fiber quality, increase harvest index, induce earliness with uniform boll bursting and facilitate mechanical harvest. They are used in HDPS cotton to manage the crop canopy and introduce partial determinateness in cotton.

What is canopy management? Why it is needed?

Canopy management is a set of mechanical or chemical practices employed over the cotton plant canopy aimed at changing the original growth pattern and architecture, thus making the plants more efficient in utilizing the growth resources-light, water, nutrients, ground space and ultimately making the crop more productive per unit area and time. Under HDPS, these practices are needed for curtailing excessive vegetative growth and retaining first formed bolls.

The practices include -

- Reducing plant height and optimizing height to node ratio either by spray of growth regulators or by mechanical/manual de- topping (nipping or the removal of terminal portion prevent apical dominance and further vegetative growth).
- Removal of unproductive vegetative branches (monopodia) and other plant parts to promote light penetration, improve aeration.
- Nipping of sympodial branches after the desired number of bolls are set.

Under HDPS these practices are needed for curtailing excessive vegetative growth and retaining the first formed bolls.

Q53 How to do canopy management manually in HDPS cotton?

Canopy management can be done manually using a secateurs/pruning shears or hand pruner or a knife blade.

Vegetative branches (monopods) are removed at 40-45 days stage. Crop height is terminated by de-topping the crop at around 90-100 cm height.

Manual removal of monopodial branch

Q54 How to do canopy management using chemicals in HDPS cotton?

Canopy management can be done spraying chemical growth retardants. Mepiquat chloride and chlormequat chloride are the common growth retardants used in HDPS cotton. Two to three sprays are given depending on the growth of the crop, soil conditions and impending weather pattern.

55 Which chemicals are approved for canopy management?

The following plant growth regulators are approved by the CIBRC for canopy management in cotton in India

Name of PGR	Purpose
Alpha Naphthyl Acetic Acid 4.5% SL(Na salt)	Reducing shedding of flower squares & bolls
Chlormequat Chloride 50% SL	Control of excessive vegetative growth and to increase crop yie ld in cotton
Gibberellic Acid 0.001%L	Promote stem elongation and some leaf enlargement, but have been shown to increase fruit retention in cotton
Mepiquat chloride 5% AS	Control of excessive vegetative growth and to increase crop yield in cotton
Triacontanol 0.05% EC	To induce flowering
Triacontanol 0.1% EW	To induce flowering

56 What are the rates of application of PGRs?

The rates of commonly used PGRs for cotton are as follows-

- Alpha Naphthyl Acetic Acid 4.5% SL (Na salt)- 20-40 ppm per spray
- Chlormequat Chloride 50% SL -20-40 g ai /ha
- Mepiquat chloride 5% AS-20-25 g ai/ha per spray

The schedule of mepiquat chloride spray standardized for rainfed cotton under HDPS by ICAR-CICR is as follows

Canopymanagement schedule	Dosage commercial formlation (Mepiquat Chloride 5% AS)
I Spray (40-45 day crop or Square initiation or crop is 40-45 cm tall)	200 ml/acre (1.0 ml/litre of water)
II Spray (15-20 days after first spray) or 60 to 65 days crop	250 ml/acre (1.2 ml/litre of water)
III spray(need based in case of excessive growth due to rains)	250 ml/acre (1.2ml/litre of water)

Q57 What are the general factors to look for timing of PGR sprays?

The number and timing of the sprays depend on the growth pattern/vigour of the variety/hybrid and its architecture, boll load, the soil moisture condition, soil depth, soil fertility, the dose of the chemical (mepiquat chloride) and impending weather forecast. In the field Height–o–ode ratio (HNR) can be calculated (by measuring plant height (cm) and then dividing it by node number) and used as a decision toll for taking up mepiquat chloride spray.

The desired plant height is to be kept in mind while calculating HNR. In general, to obtain a good crop with 90-100 cm height 20-22 nodes with an average internode length of 4.5 cm is desirable.

Under non-limiting soil moisture conditions and where no drought is forecast for the rest of the season, the following table could provide an idea if mepiquat chloride spay is needed or not.

Crop stage	Spray mepiquat chloride if HNR (cm) is
Square initiation (40-45 days)	>3.3
First flowering (60-65 days)	>4.5
Mid bloom /boll formation (80-100 days)	>5.0

Average length of top 5 internodes is also a good indicator of plant stress or excess vegetative growth. If this value is more than 4 cm (or the total length of top 5 internodes is 20 cm), a spray of mepiquat chloride would be beneficial.

These decision tools are only indicative and the ground situation may differ based on the genotype, soil conditions etc.

Q58 What are the factors critical at first spray of PGR at about 45 days after sowing?

The first spray of PGR (mepiquat chloride) is most crucial for canopy management under HDPS. This spray is given at square initiation. Under stress free situation, the crop at this stage will have around 8-10 nodes and will be more than 30 cm tall when this spray is undertaken. Factors like soil moisture stress (excess or deficit), nutrient stress may result in low plant height, may hasten or delay fruiting. The spray schedule needs to be adjusted accordingly.

59 What are the factors critical at second spray of PGR at about 60-65 days after sowing?

The second spray of mepiquat chloride at 60-65 days depends upon the effectiveness of the first spray, the prevailing weather conditions after first spray both of which reflects in the crop growth and the anticipated stress conditions. If the first spray was effective and weather was normal and the nutrient supply was adequate the HNR at this stage would be around 4.0 cm. If this is above 4.5, a second spray is recommended.

Spray of mepiquat chloride for growth regulation

60 Is a third spray of PGR required? Is it need based? How to know? And at what time it is to be sprayed normally?

The third spray of mepiquat chloride is need based. Whether a third spray of mepiquat chloride is needed or not depends upon the crop growth, varietal characteristics, soil fertility and weather conditions (particularly extended rainy period in rainfed cotton). To know whether this spray is needed or not, determine the length of the top 5 internodes. If this value exceeds 20 cm (i.e. average internode length is 4 cm), a spray may be given between 80-100 days. Beyond 110 days the boll load would normally restrict further vegetative growth.

61 How many bolls are expected per plant under HDPS?

There is no fixed number of bolls expected under HDPS. Under HDPS (90 x 15 cm spacing), if the targeted yield is 10 q/acre and the average boll weight is 4.0 g, then 9 bolls/plant (i.e. 36 gm/plant and 29,630 plants= 10.6 q) would be needed. For further details please see table under question 20.

Does boll weight vary with hybrids and canopy management?

Hybrids differ considerably in terms of boll weight. In general sympodial, early maturing, compact/semi compact hybrids would have a lower boll weight compared to bushy, monopodial, long duration hybrids. Also, the boll weight decreases in later pickings compared to the first and second. Planting hybrids or varieties under HDPS may further reduce boll weight by 5-10% in the absence of canopy management. If the canopy management sprays have been effectively undertaken, this decline in boll weight due to high density of planting can be partly compensated.

Is de-topping of plants to regulate plant height at 90 days required in HDPS?

Detopping may not be necessary in normal conditions when the recommended canopy management using PGRs is adopted. However, if canopy management is ineffective, soil is fertile, soil moisture is ample due to late season rainfall, cotton plants may grow tall. Under such circumstances if the planting was done on 90 x 15 cm spacing and the height is above 1m at 90-100 days stage, detopping may be useful. Before detopping, ensure that sympodial growth is normal and has the desired boll load.

Is foliar application of nutrient required under HDPS? Types, rate of application

Foliar application of nutrients in cotton is given only as a supplement and not as a substitute to soil application. Under HDPS, it may be needed under the following situations.

- Soil is deficient or pH is not favorable for release of nutrients particularly micronutrients.
- Root growth is restricted & limiting uptake of nutrients.
- Soil moisture stress
- Heavy rainfall has caused leaching of soil applied nutrients.
- Boll load is heavy and the crop nutrient demand is high.

Foliar Nutrition Schedule-

Crop Stage	Type & dosage
90-100 days	Multi-micronutrient (1 kg in 200 L water for 1 acre)
100-110 days	19:19:19 or 13:0:45 (3-4 kg in 200 L water for 1 acre)

If Zn deficiency exists, $ZnSO_4$ can be sprayed @ 0.5% along with 0.2% lime at flowering stage.

Is hormonal spray required under HDPS for retention of fruiting bodies?

Retention of fruiting bodies in Bt cotton under both conventional and HDPS cotton would be constrained under the following conditions-

- Prolonged cloudy weather
- Mutual shading of leaves due to excess vegetative growth
- Other abiotic stresses- high temperature, heat stress etc.

Under such circumstances a spray of Napthalene Acetic Acid (NAA) @ 20 ppm (Planofix 4.5 SL @ 0.5 ml/L water) would reduce shedding of squares and other fruiting parts.

Is pest management different in HDPS and normal sown crop?

Pest management in HDPS taken up in light soils is similar to that of conventional planted cotton.

Which pests and diseases to look for?

Boll rot due to high canopy humidity in continuous wet weather can be a problem especially in poorly drained soils. Most genotypes used in Central and South India have tolerance to jassid.

How to manage boll rot in HDPS cotton?

The microclimate, particularly relative humidity is expected to be higher under HDPS cotton compared to conventional cotton especially in medium deep soils. These conditions may prove congenial to boll rot infestation.

Prophylactic spray of copper oxychloride 50 WP/WG @25-30 g and after seven days, foliar spray of propiconazole 25 EC @10 ml **OR** Propineb 70 WP @25 g **OR** carbendazim 50 WP @4g **OR** Azoxystrobin 18.2% w/w+ Difenoconazole 11.4% w/w SC @10ml **OR** Fluxapyroxad 167 g/L + Pyraclostrobin 333 g/L SC @ 6 g mixed in 10 litres of water is suggested during flowering and early boll developmental stages to manage boll rot disease complex (bacterial and fungal) in HDPS cotton.

Boll exhibiting symptoms of boll rot

69

How to manage sucking pests in HDPS Cotton?

Use of compact genotypes with early maturity and tolerance to jassid can minimize number of pesticide sprays in the initial 50 days of crop growth. Need based sprays of eco-friendly neem formulation in BG II cotton can help in conserving natural enemies in general which are useful in regulating the pests below ETL.

70

Are ETLs different for HDPS crop?

ETLs are similar to that in cotton planted in conventional spacing.

Insect	Economic threshold level (ETL)
Sucking insects	
Jassids or leaf hoppers	25% of plants show infestation grade of II/III/IV OR 2 nymphs per leaf
Aphids	10% of plants show symptoms of cupping/ crumpling of a few leaves on the upper portion of the plant
Thrips	25% of the plants show silvery patches on the underside of leaves above mid canopy OR 10 thrips per leaf
Whiteflies	6 whiteflies per leaf
Bollworms	
American bollworm	20% of plants having one or more 'lared up'squares OR 5-10% infested square or bolls
Pink bollworm	More than 8 moths/trap per night for 3 consecutive nights and or more than 10% infested flowers or bolls (at least two bolls having live pink or white larvae)

Infestation of pink boll worm in cotton flower and cotton boll

71

What is the duration of HDPS crop?

Ideally under normal conditions, a crop planted under HDPS should be harvested in 150-160 days.

72

Is early maturity in HDPS advantageous for Pink bollworm management

Yes. Pink bollworm is a late season pest arriving in fields starting November by which time a normal sown HDPS crop would be at maturity stage and escape pink bollworm incidence. It is possible to harvest better quality cotton as well as locule damage is avoided and bolls open fully with no hard lock locules.

73

How many pickings are done in HDPS crop? And when?

Under normal conditions, only 2 pickings done at 120-130 and 150-160 days would be needed for HDPS cotton.

74

Is HDPS required for mechanical harvesting of cotton?

Although HDPS is not a pre-requisite for mechanical harvesting, planting cotton under HDPS would facilitate mechanical picking due to uniform/synchronous boll opening.

75

What are the current limitations for mechanical harvesting of cotton?

Fragmented and small land holdings, non availability of harvest aid chemicals (Defoliants and growth regulators), non availability of commercial setup for pre and post cleaning of machine harvested cotton, non availability of popular compact and synchronous genotypes amenable to mechanical picking, high initial cost of cotton harvester are limitations at present.

76

What are the pre-requisites for mechanical harvesting of cotton?

- Large contiguous land with long rows of cotton spaced far apart to accommodate picker header i.e., 70, 76, 90 cm
- Synchronised boll opening and maturity
- Availability of harvest aid chemicals for a clean and efficient pick viz., defoliants, desiccants, boll openers, re-growth inhibitors
- Management of plant height and canopy
- High density cotton planting
- Availability of pre-cleaning facility/set up to take care of trash in machine harvested cotton

Mechanical harvesting of cotton field

Q77 What are defoliants and boll openers?

Defoliants are chemicals with hormonal activity that cause leaf drying and promote leaf abscission. Thidiazuran is the most common defoliant used as a harvest aid in mechanically harvested cotton. Boll openers are chemicals used to enhance the opening of green bolls and prepare the crop for mechanical harvesting. Ethephon is the most common boll opener. Boll openers are usually tank mixed with defoliants to facilitate mechanical harvesting.

Q78 When to use defoliants and boll openers?

To obtain good defoliation and uniform boll bursting both defoliants and boll openers (tank mix or combined formulations) are sprayed at 60% boll bursting stage.

Defoliated cotton field ready for mechanical harvesting

79 How is cotton picked now? Which types of machines are used worldwide?

Cotton is mostly handpicked in India, Pakistan and Africa. In western countries majority of machines are of spindle type pickers, and about 25% are of the stripper type machines.

80 What is the effect on quality, trash content and contamination levels?

Machine-picked cotton contains more trash 17 to 20% on seed cotton basis compared to 1 to 6% found in hand harvested cotton. There is also the problem of extra moisture from the spindles which is more than the acceptable 6% desired for ginning. In machine picked cotton the leaf material is a real problem and is one of the most difficult types of trash to remove. There were no significant differences between the lint samples of hand and machine picked for the other quality factors of Fiber Length, Length Uniformity, Fiber Strength and Micronaire.

81 What is the scope for popularizing machine picking of cotton? Why is it needed in the near future?

Labour shortage and consequent increase in the cost of production, is one of the primary reasons for the need to popularize machine picking of cotton in India. Rural labour force, which traditionally engages in cotton picking, has been declining due to factors such as rural-urban migration, increased education levels, and a shift towards non-agricultural jobs. This shortage has led to increased labour costs and difficulties in finding workers during peak harvesting seasons.

However, it is important to consider the potential challenges of popularizing machine picking in India, such as the cost of machines, non availability of harvest aid chemicals viz., defoliants, adaptation to different farming practices, non availability of cleaning factories for cleaning trash from machine harvested cotton and the need for appropriate training and support for farmers. Government support, incentives, and awareness campaigns can play a crucial role in promoting the adoption of machine picking technology in the cotton sector.

82 How is shredding done in HDPS cotton field after the cotton is harvested?

Standing stalk of cotton to be shredded with tractor operated mobile cotton shredder. A multi-crop shredder operated by any ≥45 HP tractor with dual clutch and powered by PTO with 540/1000 rpm can be used to shred cotton stalks after final picking. Cotton stalks from 1 ha can be shred in 2.5 h. Shred cotton chips should be sprayed with *Trichoderma harzianum*/*T. viride* WP @ 5 g/litre of water and the shred biomass should be mixed into the soil. *Trichoderma* formulation helps in speedy decomposition and bioconversion of cotton residues.

Tractor Operated Mobile Cotton Shredder

What are the implications for farm gate sale?

This channel is preferred by majority of the small holder farmers. The main advantage of this channel is that the farmers get immediate cash payments and the seed cotton is lifted by the merchant at farm gate. Farmer has the liberty to bargain and reject of price quoted by village merchant without any financial implication. The farmers do not incur the transportation as well as loading and unloading charges. Unlike selling to CCI or ginners, there is no waiting period or queue to sell the seed cotton. The farmers receive comparatively lower price than the prevailing in the market. The basic problem with this channel is that the chances of adulteration and moisture addition are more prevalent which has a negative impact on the quality. Though it is a simple and risk free channel, there is a compromise on the quality to a greater extent.

How trash can be removed at ginnery?

For removing trash from machine harvested cotton, a factory setup consisting of following machines is required for separating different kinds of trashes from the machine picked cotton.

- Cylinder cleaner: opening the wads/locks of cotton
- Stripper: dislodging of large trash
- Stick machine: removal of large vegetable trash like burrs (empty capsule), sticks etc.
- Impact cleaner: rotational grids remove fine trashes
- Tower drier: maintains 6% moisture content for cleaning efficiency

Saw ginning has an added advantage of extra cleaning of trash from machine

harvested cotton over roller gins. However, there is a problem of fibre cut and consequently shortening of fibre.

What is GOT?

Ginning Out turn (GOT) is the ratio of lint to seed cotton and is expressed as percent by weight.
GOT=(weight of lint/weight of seed cotton ginned) x 100

Is there scope for lint-based marketing in the near future? How it is done in other countries?

Lint based marketing is prevalent in countries where cotton is predominantly harvested mechanically. Pre-requisites include adoption of high-density planting with compact genotypes for cultivation, adoption of canopy management with application of plant growth regulators, application of defoliant chemicals to remove leaves and reduce trash and boll openers for single picking of cotton using either spindle or stripper type cotton pickers and baling (lint) is done at the farm. In India, cotton is manually harvested multiple times over an extended crop period. Cotton is processed/ginned invariably at the ginner and payment received is for seed cotton. Given the present trend, lint-based marketing will take time for implementation.

What are the advantages of lint-based marketing to the farmers?

At present, commercially cultivation is with hybrids having ginning outturn between 33-35%. For every quintal processed, lint yield is 33-35 kg and seed yield is 65-67 kg. It means lint proportion is lower compared to seed. Higher lint yield is obtained with seed types having higher GoT (38-40% or higher). For every quintal of seed cotton processed, 38-40 kg lint can be realized and will be advantageous to farmers.

Is HDPS a strategy advocated pan India?

HDPS is not a strategy to be adopted in all the cotton growing areas. HDPS is best targeted to low productivity areas.

Which are the ideal zones for HDPS in India?

HDPS is best suited to agro-ecologies in shallow to medium soils under rainfed conditions in the semi-arid ecosystem using early maturing varieties/hybrids. Rainfed areas of central and south zones are ideal for HDPS cultivation.

Which are the ideal states for HDPS cultivation?

Cotton cultivated in light soil areas spread across Maharashtra, Madhya Pradesh and Telangana are ideally suited. Short season summer cotton areas of Cauvery delta in Tamil Nadu are also ideal for HDPS. Low productive districts growing cotton in shallow soils under rainfed conditions in other states like Andhra Pradesh, Karnataka and Gujarat are also suitable.

What is the economics of HDPS cultivation in rainfed areas?

Harvesting of HDPS cotton crop is completed in about 150-160 days with 2 pickings at the most. Crop management costs are lower compared to longer duration crop.

Green bolls on cotton plant after December are mostly infested with pink boll worm thereby reducing the yield substantially. Incremental increase in cost of cultivation is for higher seed rate (3 times higher/ha), extra labour for sowing but labour on weeding is reduced due to pre-emergence weedicide use, and faster canopy closure, extra dose of fertilizer (25%) due to higher plant population. Additional yield of 20-30% in rainfed cotton results in higher benefit: cost ratio compared to conventional cotton under normal spacing in shallow soils.

What are the key factors for success of HDPS?

Key factors for success of HDPS are (1) availability of genotypes with compact plant architecture (2) tailored agronomy with canopy management.

HDPS recommended in cotton cultivated under irrigation?

HDPS is recommended in cotton cultivated under rainfed conditions. In irrigated areas, higher boll number per plant is aimed with plant stands below 8000/ acre unlike in rainfed conditions where cumulative boll number per square meter is aimed at for higher productivity. With no water limited conditions, higher productivity is achieved with lower plant stands by extending the crop to provide 4-5 pickings.

Is double cropping possible after HDPS crop?

HDPS crop is mostly terminated within 150 days with 1-2 pickings. Where water is available for irrigation, it is possible to take a second crop in *rabi* such as wheat, chickpea, maize, millets, mustard, linseed etc.

Is intercropping possible in HDPS?

Yes. Intercropping is possible in HDPS but it would be difficult to adopt canopy management using PGRs under intercropping system. However, the competition offered by the intercrop would reduce excessive vegetative growth in the cotton. Short duration legumes such as black gram/green gram can be taken up in 1:1 ratio. Adjusting sowing date of intercrop (sowing 15 days after cotton) and canopy management in cotton in case of good rainfall can make intercropping profitable apart from enriching the soil in terms of nitrogen fixation in soil by rhizobacteria and improvement of soil health.

What is closer spacing?

Semi-compact genotypes are recommended for planting in medium density (closer spacing) along with canopy management by PGR sprays (mepiquat chloride) or de-topping at 90 days.

In which soils it is practiced?

Closer spacing can be taken up in medium deep, productive soils using semi-compact gentoypes in relatively assured/higher rainfall areas.

Medium deep soil profile

Cotton crop on medium deep soil

What is the spacing and the seed rate recommended for closure spacing?

Spacing for closer spacing is 90 x 30 cm (3 x 1 feet) to give a plant population of 14400 per acre in medium deep soils. Seed rate required is two times more than normal conventional wider spacing. About 3.5 to 4 seed packets per acre are required for a spacing of 90 x 30 cm.

How to do canopy management under closer spacing?

Canopy management is done similar to that in HDPS. PGR (mepiquat chloride) sprays are applied at 45, 65 and need based spray at 85-90 days. Canopy management can also be done manually by removing monopodial branches at 40-45 days after sowing and de-topping at about 90 days after sowing.

What is the duration of crop under closer planting?

Cotton under closer spacing is harvested in about 150-160 days just in time to take a second crop where water is available.

List of Abbreviations:

CIB&RC: Central Insecticides Board and Registration Committee
CITI: Confederation of Indian Textile Industries
COCPC: Committee on Crop Production and Consumption
CRDA: Cotton Development and Research Association
CS: Capsule Suspension
DAS: Days After Sowing
ETL: Economic Threshold Level
FLD: Front Line Demonstration
GOT: Ginning Out Turn
HDPS: High Density planting System
HNR: Height to Node Ratio
HT: Herbicide tolerant
ICAR: Indian Council of Agricultural Research
IR: Insect Resistance
NAA: Naphthalene Acetic Acid
NFSM: National Food Security Mission
PBW: Pink Bollworm
PGR: Plant Growth Regulator
SSI: Small Scale Industry
SSP: Single Super Phosphate
SAU: State Agricultural University
SC: Suspension concentrate
SL: Soluble Liquid
WG: Water Dispersible granule
WP: Weltable Powder

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