

*a compendium by NARS,
State Department(s) of Agriculture and Agro-Industries*

Districtwise Promising Technologies for Rainfed Cotton based Production System in India



**All India Coordinated Research Project for Dryland Agriculture
Central Research Institute for Dryland Agriculture**

Santoshnagar, Hyderabad 500 059

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About this compendium

Crop based recommendations are available from several sources for location specific conditions. However, in rainfed region there are several crops grown in combination or individually at most of the places. Hence, a ready reckoner should provide information not only for growing a healthy crop but also to meet the aberrant weather conditions in that region. At present, districts which contribute to 85% of rainfed cotton region, were identified. Their agro ecological setting, soil and water conservation, crop management including nutrient management, pest management etc., suitable cropping systems, alternate farming systems, contingency plans etc., are described in the background of crop yield gap and runoff of the district. The technologies encompass not only that from All India Coordinated Research Project for Dryland Agriculture (AICRPDA) and All India Coordinated Cotton Improvement Project (AICCIP), but also others from National Agricultural Research System (NARS), State Department(s) of Agriculture and Agro-industries.

*a compendium of AICRPDA, CRIDA, AICCIP, SAUs,
State Department(s) of Agriculture and Agro-Industries*

Districtwise Promising Technologies for Rainfed Cotton based Production System in India

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Agro-Industries

Fertilizers
Implements
Pesticides
Seeds

State Department(s) of Agriculture

Andhra Pradesh
Gujarat
Karnataka
Madhya Pradesh
Maharashtra
Tamilnadu

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Cotton Based Production System

Cotton assumes a place of significance in Indian agriculture and economy due to its role in providing employment to millions of people, earning valuable foreign exchange and improving the economy of farmers. All the four cultivable species and their hybrids are grown in India under diverse agro-ecological and farming conditions. India has made significant strides since independence in improving the production, productivity and fibre quality resulting in meeting the domestic requirements as well as export.

Cotton (*Gossypium sp.*) is one of the most important commercial crops playing a key role in economics. In India, cotton is cultivated in 7.8 million hectares in varied agro-ecological conditions across nine major states. Cotton cultivation offers employment of 200 mandays/ha annually. It employs directly and indirectly more than 60 million persons in its production, processing and marketing. India has the largest area under cotton, but its production is just 15.2 million bales, much lower for the vast area. Cotton is grown on a variety of soils. In cotton selection of soil is very important. Soil should be black medium to deep (90cm) having good drainage availability. Cotton does not tolerate waterlogging condition. It is grown mainly as a dry crop in the black cotton and medium black soils.

Cotton is a tropical and subtropical crop. For the successful germination of its seeds, a minimum temperature of 15° C is required. The optimum temperature range for vegetative growth is 21° - 27° C. It can tolerate temperatures as high as 43°C, but does not grow well if the temperature falls below 21°C. During the period of fruiting, warm days and cool nights with large diurnal variations are conducive to good boll and fibre development.

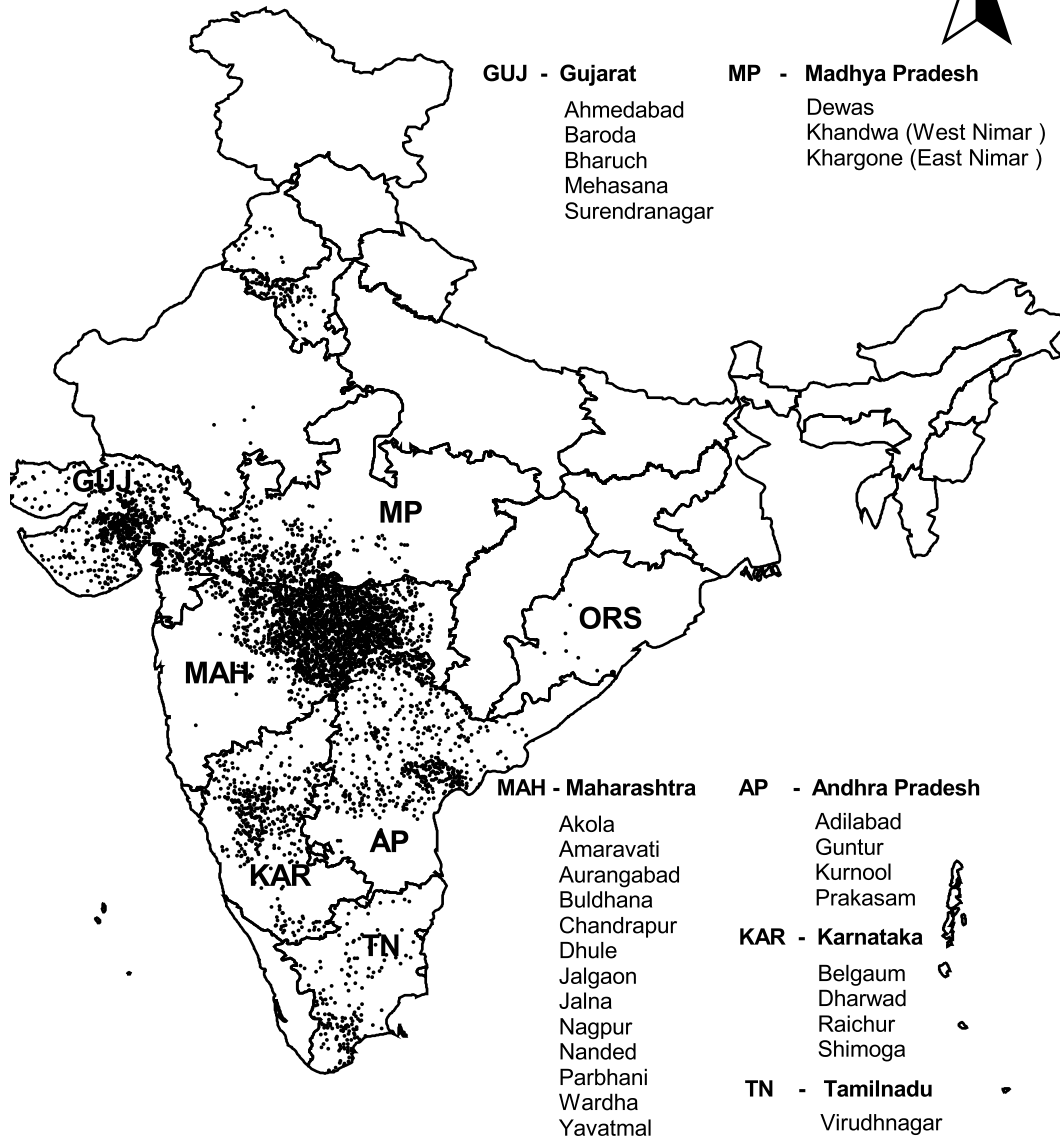
Cotton is grown in 7.8 m ha in 296 districts of which 5.1 m ha is rainfed in sixteen states viz. Bihar, Orissa, Chattisgarh, Madhya Pradesh, Maharashtra, Uttar Pradesh, West Bengal, Jharkhand, Karnataka, Andhra Pradesh, Tamil Nadu, Gujarat, Rajasthan, Punjab and Uttaranchal. About 85 per cent of the rainfed cotton is grown in 30 districts (4.1 m ha).

Selection criteria	No. of districts	Area under Cotton ('000 ha)	Area under Rainfed Area ('000 ha)	Gross Cropped	Yield (kg/ha)
Sixteen states	296	7757	5171	157528	170
Agro Eco Region 3-13	237	6064	4892	126780	171
80% Rainfed Cotton Area	30	4587	4143	22791	180

Statistically significant trends in cotton area and yield growth rates for different districts follows:			
Area	Yield	State	Districts
Stagnant	Increasing	Andhra Pradesh Karnataka Madhya Pradesh Maharashtra	Kurnool Dharwad Dewas Jalgaon
Stagnant	Stagnant	Gujarat Madhya Pradesh Maharashtra	Mehasana Khandwa Nanded, Buldana, Dhule
Decreasing	Stagnant	Gujarat Karnataka	Baroda, Bharuch Raichur
Increasing	Increasing	Karnataka Maharashtra	Belgaum, Shimoga Chandrapur
Decreasing	Increasing	Maharashtra	Amaravati, Akola, Wardha, Nagpur

RAINFED COTTON REGION

Priority Districts



Some popular cotton production systems existing in various Agro-ecoregions (AERs) is presented below:

Agro-ecoregion	Production System
Hot Arid Karnataka Plateau (Rayalaseema inclusion)	Finger millet/ Groundnut/ Pearl millet- Cotton
Hot Semiarid Northern Plains and Central Highlands	Cotton-Fallows Cotton+ Blackgram
Hot Semiarid Central Highlands (Malwa)	Cotton- fallow Cotton-Sorghum-Groundnut (3yrs) Sorghum-Cotton Cotton+ Blackgram
Hot Semiarid Deccan Plateau	Pearl millet- Cotton Cotton+ Pigeonpea Cotton+ Greengram
Hot Semiarid Eastern Ghats and Deccan (Karnataka) Plateau	Cotton- Sorghum

Details on associated crops and livestock population are presented below:

Crops	Animals	Districts
Cotton	Goats	Dewas, Khargone, Khandwa, Adilabad, Shimoga, Parbhani, Nanded, Buldana,
Vegetables	Male Cattle	Akola, Amaravati, Yavatmal, Wardha, Nagpur, Chandrapur
	Female Cattle	Bharuch, Baroda, Surendranagar
Cotton	Sheep	Guntur, Kurnool, Dharwad, Belgaum, Raichur, Mehasana, Prakasam
Groundnut	Goats	
Pearl millet	Female Buffalo	
Sunflower	Male Cattle	
Vegetables		
Pearl millet	Goats	Dhule, Jalgaon, Aurangabad, Jalna
Cotton	Male Cattle	
Vegetables	Female cattle	

Some issues and strategies are -

Crop Production

Cotton based cropping system productivity and profitability

- Cropping systems in various forms, like mixed cropping system, are adopted in traditional dryland agriculture, which act mainly as risk cover against crop failures due to vagaries of monsoon pest attack. Mixed cropping with sorghum, pigeonpea, maize or pulses in Central India and with groundnut, *ragi* or millets in parts of south India is a common system followed. In Punjab and Haryana, mixture of *moth* and *guar* with cotton was in vogue before the advent of short duration cultivars.
- Cotton-based cropping system on new approaches could be considered depending upon the rainfall (amount, distributing and length of season) and type of soil. Profitable intercropping systems are possible with range of rainfall between 600-750 mm and on soils with moisture storage capacity of 100 upto 150 mm. With rainfall upto 900 mm and soils with moisture storage capacity upto 200 mm, relay and sequence cropping systems can be developed
- Choice of suitable genotypes to suit alternative planting pattern of cotton and intercrop; and their proportions for maximizing the profitability of the system as a whole, fertilizer economy for higher yields,

as well as effecting N economy by introducing suitable legumes, moisture conservation through live mulch, adoption of suitable weed control measures etc. are some approaches on which research emphasis should be laid in future.

- Cropping systems for different zones (inter and sequence cropping) may be evolved, taking into account cost of cultivation, higher productivity and land equivalent ratios (LER). The effect of cropping system on changes in soil fertility may be studied. Economics of different cropping systems will be worked out.
- In irrigated tracts of south zone, the land holding ranges from 0.5 to 3 ha
- In north zone cotton tract with high bollworm incidence, organic cotton is almost negligible, except in limited desi cotton areas. In Central and south zone, rainfed desi is predominantly organic with low level of inorganic fertilisers/ insecticides. Rainfed *hirsutum*s in certain pockets and most *herbaceum*s are organic.
- With development of special genotypes for organic farming conditions for various zones, Bt gene based transgenic cottons and other genetically resistant types for biotic stress etc., environmental toxicity on cotton can be reduced.
- In Gujarat state, V 797, G.Cot 13, Dhumad are grown as organic cotton and are suitable for rotor spinning, blending for hosiery making and stuffing
- Use of *Azotobacter*, *Azospirillum* along with organic matter, phosphate solubilising micro-organisms (PSM) etc., instead of inorganics, may be encouraged.
- Genetic stocks in gene bank contain 20-30 coloured linted genotypes. They have inferior yield potential and fibre quality especially strength, maturity and colour stability. Brown, shades of brown and tree, Khaki are available both in *hirsutum*/desi cotton and are from India, U.S.A., Russia etc.
- There is small demand for coloured cotton in international market
- Coloured cotton needs research for developing major colours with high colour stability, high yield and fit for organic farming conditions and good staple of 26-27 mm with high fibre strength, optimum micromere and other superior attributes.

Soil Management

- Loamy to sandy loam soil with effective drainage system in north zone is highly suitable. Soil temperature is high at sowing, while soils are low in nutrient status.
- In Central and south zone, deep vertisols (black loamy soils) are good for hybrids and *hirsutum*s. Desi cottons have now been confined to marginal and shallow soils. Red loamy soils are also good in south zone pockets
- pH value of soils of 5.5 to 8.5 are most suited for cotton
- Use of organic matter helps to improve the yield

Efficient Implements

- Hand picked cottons in India are superior to machine picked cottons else where (cleaner with less trash and dust and good colour)
- In north zone, average land holding in cotton belt is 4 ha. Tractor mounted seed plating drills and spray pumps and self propelled spray pumps etc. are economical to use in such holdings

In rainfed areas of Maharashtra, Madhya Pradesh, Andhra Pradesh, Gujarat and Tamil Nadu, the land holding of cotton varies from 1 to 5 hectares but marginal farmers are predominant

Water Management

- Lack of proper moisture conservation/untimely rainfall/cloudy weather continuously/non adoption of advance sowing methodologies/non-planting in contour gradient/non use of tied ridge system/rain water harvesting and recycling not followed/intercropping practice beneficial but not adopted/ no drip or sprinkler irrigation/ no plant protection in many holdings/growing in unsuitable lands/ technology for resources/input constraints required.
- Effective use of non monetary inputs like early sowing, avoidance of weed competition, optimum plant population, bio-fertilizers and timely plant protection. Rain alone responsible for 40% variation in yield in Sudan and so also in India/build up stability of yield components through varietal improvement and crop management technology

Drip irrigation in cotton

- One of the reasons for low yield of seed cotton in India is its cultivation on lighter/shallow soils, and inefficient water management, cotton on 70% of the rainfed area suffers from water stress at the crucial phase of boll development, and from inefficient water management on rest of the irrigated areas, facing problems of drainage and rising salinity.
- Drip irrigation system attains relevance here for saving in water consumption to the tune of 40% over conventional irrigation system, and with higher productivity of cotton, the water use efficiency is high. Other advantages, like fertiliser saving upto 30% through fertigation, uniform maturity with optimum fibre quality, and culturability of sloppy and lighter soils and partial use of saline water, are also envisaged. With targeted yield form 2-2.5 t/ha under drip system, the installation cost can be recovered within 2 years.

Marketing/pricing of cotton

- With increased access to global market, effect of quality parameters on market prices of cotton has to be monitored; as in international market, quality will be stressed upon.

Research – Extension linkages and transfer of technology

- Big gap between potential yield, demonstrated yield and actual
- Technology delivery system is not effective: Technology dissemination needs toning up Krishi Vigyan Kendra concept and mass training useful, farmer participatory mode through promising NGOs shall be explored.

Quality seed requirements and role of various agencies

- Certified seed is required for present need up to 6000 t and at 7600 tonnes/ year in the 2000's
- Better coordination between seed units of government and private sector seed companies for timely availability of seeds after grow-out tests and certification.

Estimation of Area and production

- There are conflicting interests in publishing the estimated area, and particularly production
- The Ministry of Agriculture estimates are rather conservative and on the lower side

Cotton vis-à-vis synthetic and other natural fibres

- In addition to the use of synthetics, the incorporation of coming years. In addition to the use of synthetics, the incorporation of jute and allied fibres including sunhemp, ramie, Agave, banana, pineapple pulp, etc. may have to be considered appropriately, if not for production of textiles and garments, at least for the manufacture of rough cloth for some specific needs in the futuristic scenario, as to develop a wide range of use pattern for the natural fibres and bring about value addition.

Crop Improvement

Hybrids vs. Varieties

- In desi hybrids, the workability of GMS system is yet to be demonstrated and needs intensive study
- In HH and HB hybrids also GMS/CMS-P conversion needs intensification
- The cost of hybrid seed has increased and there is need for reducing the cost of production by various means and offering at lower prices
- Hybrids under good management should yield at least 30 to 40% more than varieties
- There is need for strong complementary research/development programmes for both hybrids and varieties so that the full potentials and practical advantages of both can be harmonized
- Hybrids perform better under higher input technology conditions and superior management

Arboreum vs. Hirsutum

- Development of intra-*hirsutum* hybrids (F₁) since 1970s and their popularity in commercial cultivation even under assured rainfall condition in Maharashtra, Andhra Pradesh, Madhya Pradesh etc. caused further replacement of desi cottons particularly *arboreums*. Intra-*hirsutum* hybrids and high yielding varieties with higher yield level and premium price in the market also provided impetus to replacement of traditional Asiatic cottons.

Crop Protection

Insect management (conventional vs. biocontrol based)

- Insect management has gained importance as pests (insects and diseases) take a toll of 30-60% yield per year from cotton crop all over the country
- Predominant loss is caused by *Heliothis*, *Earias*, *pectinophora*, Jassids and whitefly
- Over 50% the total insecticides in agriculture are used in cotton and pest control accounts for 35-60% of the cost of cultivation charges
- Seed treatment against disease is quite satisfactory (delinting and organomercurials).
- Promote pest surveillance, pest forecasting and directions for timely plant protection, use of remote sensing etc.
- Follow ecologically viable and economically feasible systems of IPM – Crop surveillance mechanism/ pesticides preparedness in terms of quality, type and quantity on time/threat of whitefly and new leaf curl virus to be faced/crop husbandry measures like rotation, genetic resistance, crop sanitation, control of weeds, non ratooning, monitoring economic threshold limit by pheromones/scouting etc., biological suppression/judicious chemical suppression/ action threshold/bio-pesticides

Surveillance and management of cotton diseases

- Shift in the cotton disease scenario is mainly governed by the type and extent of *Gossypium sp.* Cultivated, subtle year to year variations in climatic features of different regions and introduction of novel pathogens from across the countries border
- Thus, disease which were not important on the diploid “Desi” varieties exclusively grown up to early sixties over a large area have attained prominence on the tetraploid *hirsutums* and hybrids, e.g. bacterial blight. On the contrary, grey mildew was a serious problem on diploids in the early 50’s but became endemic tetraploids.
- A constant and close watch by the National Institute on the disease situation in India has helped us in understanding important disease problems and devising strategies for their effective management.
- Leaf curl has recently got introduced in the border areas of Rajasthan and Punjab and is now a matter of great concern as it threatens to advance further to other cotton growing areas gradually

- Our task is to understand the etiology and epidemiology of these diseases and to develop location specific management strategies
- Integrated disease management system needs to be developed in different cotton eco-zones

Yield gap and rainfall surplus index of productivity zones

The districts in a crop region vary in productivity, annual normal rainfall and length of growing period. The later two identifies with an agro eco region, while the former with a crop based production system. By taking these three attributes, a cluster analysis is made and optimum number of clusters were identified. The districts under each of the crops were taken as a group. For these groups of districts based on area, the runoff and surplus index (ratio of runoff to average annual normal rainfall) was calculated (Thornthwaite and Mather method). The surplus index was divided into three groups – Low (less than 12%), medium (12-25%) and high (more than 25%). Necessary soil and water conservation methods were identified the details follow:

Rainfall Surplus Index	Possible Options
<12	<i>In situ</i> conservation
12-25	<i>In situ</i> conservation and water harvesting
>25	Drainage, <i>in situ</i> conservation and water harvesting

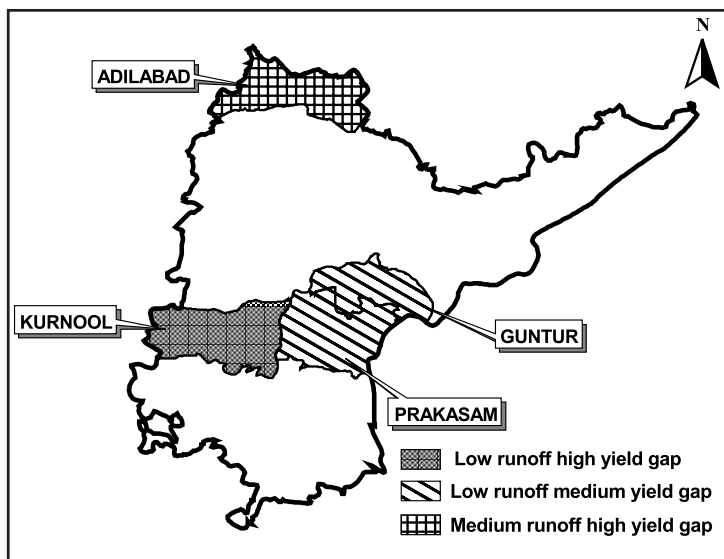
Regular the yield gap was grouped as low (< 33%), Medium (33-66 %) and high (>66%). The possible options are –

Yield Gap	Possible Options
<33	Non monetary inputs and improved varieties
33-66	Non monetary inputs, fertilizer management and improved varieties
>66	Improved varieties, fertilizer management, plant protection measures, non monetary inputs or shifting alternate land uses

These three attributes – productivity of a crop (average yield 1990-91 to 1994-95), annual rainfall (mean of past 30 years) was used for yield gap (from 0.7 of achievable yield based on water requirement satisfaction index) and runoff estimations. Strategies were matched with the matrix of surplus index requirement in the districts by utilizing the surplus rainfall. Each of the dominant districts of a particular crop was grouped into the possible combinations of surplus index (3) and yield gap (3) under nine combinations. Recommendations were derived for these groups from the nearest research center consisting of network of research of National Agricultural Research System (NARS). Recommendations are given for Cotton based production system, state-wise and group (s) of districts. These consist of soil and water conservation, crop management (varieties, seed rate, planting pattern, nutrient management, pest management, suitable cropping systems, farm implements/ tools, alternate farming systems, and contingent planning. A region was described in terms of agro-ecological setting i.e., climate, physiography, soils, annual rainfall, potential evapotranspiration (PET), and moisture availability period. The identified priorities for increasing the productivity in short term are also included.

ANDHRA PRADESH

In Andhra Pradesh, there is one district viz., Adilabad under medium runoff and high yield gap region, two districts viz., Guntur and Prakasam under low runoff and medium yield gap region and one district viz., Kurnool under low runoff and high yield gap region



District	Region
Adilabad	Medium runoff and High yield gap

Agro-ecological setting

- **Climate:** Hot moist semi arid
- **Physiography:** North Western Telangana Plateau
- **Soils:** Shallow and medium loamy, medium and deep clayey black soils (Vertic Inceptisols – 50%; Alfisols – 50%)
- **Annual rainfall:** 992 mm
- **Potential evapotranspiration:** 1689 mm
- **Moisture availability period:** 120 – 150 days

Soil and water conservation

- More emphasis on *in situ* moisture conservation
- Increasing soil infiltration capacity and reducing soil crusting problem

Crop management

- **Varieties:** B 1007, LRA 5166, LPS 141, JKHY – 1, NHH 44, Savita
- **Seed rate:** 10-12 kg/ha –varieties; 2-3 kg/ha – Hybrids
- **Date of sowing:** 25th June to 8th July

- **Planting pattern:** Varieties - 75 x 30 cm; Hybrids - 90 – 120 x 60 cm
- Nutrient management:
 - Hilly areas
 - 60 kg N + 40 kg P₂O₅ for Varieties
 - 90 kg N + 45 kg P₂O₅ for Hybrids
 - Plains for varieties
 - 40 kg N + 20 kg P₂O₅ + 20 kg K₂O/ha

Pest management

- Summer ploughing
- Avoid delayed sowings
- Use of certified seeds
- Seed treatment with Captan or Thiram @ 2-3 g/kg seed
- Destruction of weeds
- Intercropping with blackgram, soybean, groundnut, setaria, maize, cowpea at two rows for every ten rows of cotton
- Trap cropping with Okra (1:10), castor, marigold
- Use of egg parasitoids *Trichogramma* sp.@ 1.5 lakh/ha
- Spray H-NPV @ 250 LE/ha
- Use of Neem oil 5%
- Spray of Quinalphos @2 l/ha or Chloripyriphos @ 2 l/ha
- Weeding at 30 days after semi and of 60 days after sowing

Some other important practices

- Sowing in June/ July

Suitable cropping systems

- Cotton + pigeonpea
- Cotton + sorghum

Farm implements/ tools

- Ferti cum seed drill
- Bullock drawn two-row sweep cultivator
- Modified two-row blade harrow
- Bullock drawn country plough attached with Pora tube

Alternate farming systems

- Parkland systems: *Azadirachta indica*, *Acacia nilotica*, *Tamarindus indica*
- Trees on bunds: *Tectona grandis*, *Leucaena leucocephala*, *Borassus flabellifera*, *Coccos nucifera*, *Acacia nilotica* var. *cupressiformis*

- Silvicultural system: *Leucaena leucocephala* + *Stylosanthes hamata*, *Leucaena leucocephala* + *Cenchrus ciliaris*
- Alley cropping: *Leucaena leucocephala* + sorghum/ Pearl millet, *Gliricidia sepium* + sorghum/pearlmillet
- Agrohorti system: Mango + short duration pulses
- Fruit: Mango, Ber, Custard apple, Guava, Pomegranate, Amla
- Fodder/green biomass: *Leucaena leucocephala*, *Azadirachta indica*, *Albizia lebbeck*, *Bauhinia purpurea*, *Acacia procera*, *Butea monosperma*, *Acacia samara*, *Dalbergia sissoo*
- Medicinal & Aromatic Plants: *Catharanthus roseus*, *Cassia angustifolia*, *Aloe barbadensis*, *Withia somnifera*, *Cymbopogon martini*, *Cymbopogon flexuosus*, *Vetiveria zizanioides*, *Prosalea*, *Palma rosa*.
- Dye yielding plants: *Lawsonia inermis*, *Hibiscus sabdariffa*, *Tagetes erecta*, *Indigofera tinctoria*, *Annato*
- Other economic shrubs: Curry leaf, Jatropha, Soapnut
- Animal component: Female cattle, Female Buffaloes, Male Cattle, Sheep and Goat
- Other enterprises: Sericulture, Poultry

Contingent planning

For Red soils:

- **June:**
 - **Sole crop:**
 - Sorghum (CSH 5, CSH-6, CSH-9), Pearl millet (MBH 110)
 - **Intercrop:**
 - Sorghum- pigeonpea (2:1)
 - Pearl millet + pigeonpea (2:1) in 45 cm row spacing. Pigeonpea duration of 150 – 180 days may be used.
- **July:**
 - **Sole crop:**
 - Fingermillet
 - Sow castor (Kranti, GAUCH-1)
 - Bunch variety of Groundnut (TMV-2, JL-24)
 - **Intercrop:**
 - Maize (DHM-101.Ganga-5)
 - Maize + pigeonpea (2:1) at 50 cm spacing. Pigeonpea duration of 180-200 days
- **August:**
 - **Sole crop:**
 - Setaria (H-1, Arjuna) for grain to poultry feed and straw for fodder
 - Castor (Kranti, Aruna, GAUCH –1) with increased seed rate (15 kg/ha)

For Black soils

First crop

- **June:**
 - Sorghum (CSH-5, CSH-6)

- Maize: (Ganga 5, DHM-101)
- Greengram (PS-16, HB-45, LRG –30)
- **July:**
 - Maize (Ganga 5, DHM-101)
 - Greengram (PS-16, HB-45, LRG –30)

Second crop

- **September:**
 - *Maghi* sorghum (Moti, CSH-6)
 - Safflower: (Manjira)
- **October:**
 - Safflower: (Manjira)
 - Chickpea (Jyothi)

District	Region
Guntur Prakasam	Low runoff and Medium yield gap

Agro-ecological setting

Guntur

- **Climate:** Hot moist semi arid/ dry sub humid
- **Physiography:** Eastern ghats
- **Soils:** Medium deep loamy, clayey mix red and black soils, deep clayey coastal and deltaic alluvium derived soils (Aridisols – 40%; Vertisols – 30%; Alfisols – 30%)
- **Annual rainfall:** 704 mm
- **Potential evapotranspiration:** 1777 mm
- **Moisture availability period:** 150 - 180 days

Prakasam

- **Climate:** Hot moist semi arid/ Dry sub humid
- **Physiography:** Eastern Ghats
- **Soils:** Medium deep loamy, clayey mixed red and black soils, deep clayey coastal and deltaic alluvium derived soils (Vertic Inceptisols – 70%; Orthids – 30%)
- **Annual rainfall:** 848 mm
- **Potential evapotranspiration:** 1951 mm
- **Moisture availability period:** 150 – 180 days

Soil and water conservation

Guntur, Prakasam

- More emphasis on *in situ* water conservation like mulching, deep tillage, conservation furrows
- Increasing soil infiltration capacity and reducing soil crusting problem
- Supplemental irrigation wherever feasible

- Field bunds for smaller areas may be encouraged for wider adoption

Crop management

Guntur, Prakasam

- **Cultivars:**
 - L 389, MCH 5, LRA 5166, JKHY 1, Savita, LAM Hybrid 1
- **Seed rate:** 8- 10 kg/ha
- **Date of sowing:** 15th July to 15th August
- **Planting pattern:** 90 x 45 cm; 105 x 45 cm; 90 x 60 cm; 105 x 60 cm
- **Nutrient management**
 - 90 kg N (in two splits i.e., half at first square formation and half at peak flowering) + 45 kg P₂O₅ + 45 kg K₂O + 10-15 t FYM/ ha. Entire P and K at sowing
 - 100 kg N (in two splits i.e., half at first square formation and half at peak flowering) + 50 kg P₂O₅ + 50 kg K₂O + 10-15 t FYM/ ha. Entire P and K at sowing
- **Pest management**
 - Summer ploughing
 - Avoid delayed sowings
 - Use of certified seeds
 - Seed treatment with Captan or Thiram @ 2-3 g/kg seed
 - Destruction of weeds
 - Intercropping with blackgram, soybean, groundnut, setaria, maize, cowpea at two rows for every ten rows of cotton
 - Trap cropping with Okra (1:10), castor, marigold
 - Use of egg parasitoids *Trichogramma* sp.@ 1.5 lakh/ha
 - Spray H-NPV @ 250 LE/ha
 - Use of Neem oil 5%
 - Spray of Quinolphos @2 l/ha or Chloripyriphos @ 2 l/ha
 - Weeding at 30 days after semi and of 60 days after sowing
- **Some other important practices**
 - Sowing up to 15th July in red soils
 - Sowing up to 15th August in black soils
 - Sowing upto June second fortnight (Alfisols)
 - Sowing upto second fortnight of July (deep black soils)

Suitable cropping systems

Guntur, Prakasam

- Cotton + pigeonpea

Farm implements/ tools

Guntur, Prakasam

- Bullock drawn two-row sweep cultivator
- Modified two-row blade harrow
- Bullock drawn country plough attached with Pora tube.

Alternate Farming systems

Guntur, Prakasam

- Fodder/ green biomass: *Albizia lebbbeck*, *Dalbergia sissoo*, *Leucaena*, *Azadirachta*, *Hardwickia binata*, *Acacia albida*
- Fruit: Custard apple, tamarind, jamun, mango, ber
- Medicinal/ Aromatic Plants: *Cassia angustifolia*, *Catharanthus roseus*, *Plantago ovata*, *Palma rosa*, *Vetiveria zyzanoides*
- Vegetables: Cluster bean, drumstick, cucumber, cowpea, ridge gourd, round melon, okra, watermelon.

District	Region
Kurnool	Low runoff and High yield gap

Agro-ecological setting

- **Climate:** Hot dry semi arid
- **Physiography:** Rayalseema
- **Soils:** Deep loamy, clayey mixed red and black soils (Alfisols – 60%; Vertic Inceptisols – 40%)
- **Annual rainfall:** 605 mm
- **Potential evapotranspiration:** 1828 mm
- **Moisture availability period:** 80 – 120 days

Soil and water conservation

- Contour bunds, graded bunds
- Contour bunding with a cross section of 0.63m² and with horizontal spacing of 25m to 125m is recommended for red soils. The other soil conservation measures like Compartment bunds of 15m length and 10m width or conservation furrow at 3.6m interval or intercropping with mixed pulses like cowpea and horsegram can be adopted.
- Integrated watershed management (manage in a < 10 ha watershed)
- Water harvesting in lined with cuddapah slabs to avoid seepage losses dug out ponds
- Increasing catchment area and design of pond size for catchment size
- Interplot water harvesting of 1:1 cropped to uncropped area
- Use of life saving irrigation
- Improvement of indigenous water harvesting structures

Crop management

- **Varieties:** Mahanandi, NA – 920
- **Seed rate:** 10-12 kg/ha; 3-3.5 kg/ha for Hybrids
- **Planting pattern:**
 - 60 – 68 x 22 cm for *Desi* cotton
 - 60 x 30 cm for *American* cotton

- **Nutrient management**

- 90 kg N (in two splits i.e., half at first square formation and half at peak flowering) + 45 kg P₂O₅ + 45 kg K₂O + 10-15 t FYM/ ha. Entire P and K at sowing
- 100 kg N (in two splits i.e., half at first square formation and half at peak flowering) + 50 kg P₂O₅ + 50 kg K₂O + 10-15 t FYM/ ha. Entire P and K at sowing

- **Pest management:**

- Summer ploughing
- Avoid delayed sowings
- Use of certified seeds
- Seed treatment with Captan or Thiram @ 2-3 g/kg seed
- Destruction of weeds
- Intercropping with blackgram, soybean, groundnut, setaria, maize, cowpea at two rows for every ten rows of cotton
- Trap cropping with Okra (1:10), castor, marigold
- Use of egg parasitoids *Trichogramma* sp.@ 1.5 lakh/ha
- Spray H-NPV @ 250 LE/ha
- Use of Neem oil 5%
- Spray of Quinolphos @2 l/ha or Chloripyriphos @ 2 l/ha
- Weeding at 30 days after semi and of 60 days after sowing
- Fluchloralin @ 1.0 kg a.i./ha or Pendamethalin @1.5 kg a.i./ha Preplanting application with one interculture 35 days after sowing

- **Some other important practices**

- Mungani – Sowing in May last week and first week of June
- Hingari – Second fortnight of August onwards for *Desi* cottons
- August 15th to September 15th – American cotton
- Seed treatment of with *Azospirillum* or *Azotobacter*
- Mulching with crop residues
- Providing good internal and surface drainage
- Deep ploughing once in 2-3 years

Farm implements/ tools

- Eenatigorry (bullock drawn, four row): Useful for sowing, seed and fertilizer placement. Suitable for those who have light draft animals: (Rs.1500 per unit)
- Seed drill/planter (tractor drawn, nine row): It is a mechanical seed drill. More area can covered in a day and intra row spacing is maintained (Rs.16000 per unit)
- Ashaguntaka (tractor drawn, seven row): Useful for harvesting of groundnut crop. More field capacity and labour saving (Rs.20000 per unit)
- Groundnut thresher cum decorticator: Useful for separating groundnut pods from haulms. It was found advantageous to thresh groundnut after 3-5 days after harvest. The cost of operation was Rs. 224/ha. It can also be used as decorticator with minor modifications. Perform timely operation and labour saving (Rs.45000 per unit)
- APAU groundnut seed cum fertilizer drill (three row – animal drawn)
- CRIDA seed cum fertilizer drill (four row – animal drawn)
- Groundnut thresher

Alternate farming systems

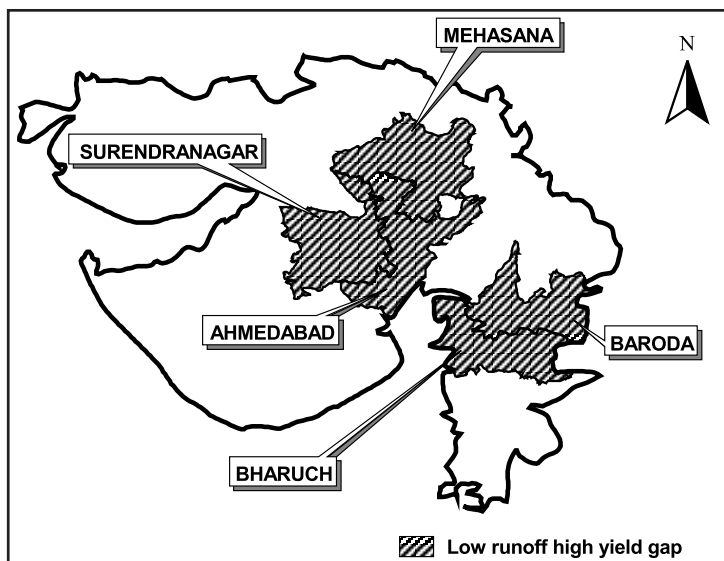
- **Fodder/ green biomass:** *Dalbergia sissoo*, *Gliricidia*, *Albizia lebbbeck*, *Cassia siamea*, *Azadirachta indica*/ stylo, Marvel-8 grass
- **Fruit:** Ber, Custard apple, Pomegranate, Amla + in *kharif* spreading crops
- **Medicinal and aromatic plants:** *Cassia angustifolia*, *Catharanthus roseus*, *Palma rosa*, *Vetiveria zizanooides*, Rose, Geranium
- **Vegetables:** Onion, Brinjal, Chillies, Cowpea, Cucumber, Cluster bean, Drumstick.
- Crop + livestock (sheep @ 10/ha) system of farming will give 80% more income than crop system alone.

Contingent crop planning

- Early onset of monsoon (last week of May or in June): Sorghum (CSH-5), greengram, pigeonpea (PDM-1), castor (Aruna, GAUCH -1), mesta (AMV -1)
- Normal onset of monsoon (July): Groundnut, pigeonpea (TMV -2,J-11), groundnut + pigeonpea, castor (Aruna, GAUCH -1), mesta (AMV -1), setaria, pearl millet (MBH -110, MH-88), greengram
- Late onset of monsoon (August): Sorghum, greengram (after August 15th), pearl millet (MBH -110), setaria, groundnut (TMV -2)
- Very late onset of monsoon (September): Pearl millet, cowpea, horse gram (early September), pearl millet (MBH -110), horsegram (Anantapur local, BGM)

GUJARAT

In Gujarat there are five districts viz. Ahmedabad, Baroda, Bharuch, Mehasana and Surendranagar under low runoff and high yield gap region.



District	Region
Ahmedabad Baroda Bharuch Mehasana Surendranagar	Low runoff and High yield gap

Agro-ecological setting

Ahmedabad

- **Climate:** Hot dry semi arid
- **Physiography:** North Gujarat Plains
- **Soils:** Deep loamy grey brown and alluvium - derived soils, shallow and medium loamy to clayey black soils, deep black soils (Alfisols/ Mollisols – 100%)
- **Annual rainfall:** 823 mm
- **Potential evapotranspiration:** 1678 mm
- **Moisture availability period:** 90–120 days

Baroda

- **Climate:**
- **Physiography:** Eastern Gujarat Plains
- **Soils:** Vertic Inceptisols– 55%; Vertisols – 45%

- **Annual rainfall:** 987 mm
- **Potential evapotranspiration:** 1575 mm
- **Moisture availability period:** 60 – 90 days

Bharuch

- **Climate:** Very hot moist semi arid
- **Physiography:** Eastern Gujarat Plains
- **Soils:** Medium to deep clayey black soils (shallow black soils an inclusion)
- **Annual rainfall:** 1002 mm
- **Potential evapotranspiration:** 1725 mm
- **Moisture availability period:** 120-150 days

Mehasana

- **Climate:** Hot arid / Hot dry semi arid
- **Physiography:** North Gujarat Plains
- **Soils:** Deep loamy desert soils, deep loamy grey brown and alluvium - derived soils (Alfisols/ Mollisols–100%)
- **Annual rainfall:** 507 mm
- **Potential evapotranspiration:** 1988 mm
- **Moisture availability period:** 60 – 120 days

Surendranagar

- **Climate:** Hot arid/ dry semi arid
- **Physiography:** North Kathiawad Peninsula
- **Soils:** Deep loamy desert soils, deep loamy saline and alkaline soils, deep loamy grey brown and alluvium - derived soils (Alfisols/ Mollisols – 60%; Vertic Inceptisols – 40%)
- **Annual rainfall:** 601 mm
- **Potential evapotranspiration:** 1970 mm
- **Moisture availability period:** 60–120 days

Soil and water conservation

Ahmedabad

- Shallow ploughing before sowing
- Ridging and furrowing 25 days after sowing
- *In situ* moisture measures like mulching, tillage, conservation furrows etc
- Indigenous water harvesting structures wherever topography permits

Baroda (Vadodara), Bharuch

- More emphasis on *in situ* moisture conservation
- Increasing soil infiltration capacity and reducing soil crusting problem

- Absorption terracing
- Inter-row water harvesting
- Dead furrows at 3.6 m intervals

Mehasana

- Shallow ploughing before sowing and ridging and furrowing 25 days after sowing.
- Increasing soil infiltration capacity and reducing soil crusting problem
- Two to four interculturings along with deep ploughing in groundnut

Surendranagar

- More emphasis on *insitu* water conservation
- Increasing soil infiltration capacity and reducing soil crusting problem
- Absorption terracing
- Inter-row water harvesting
- Dead furrows at 3.6 m interval

Crop management

Baroda, Bharuch, Mehasana

- **Varieties:** G. Cot – 10, G. Cot – 13, G. Cot – 15, G. Cot – 18, G. Cot – 21, V -797
- **Seed rate:** 12 – 15 kg/ha
- **Date of Sowing:** 1st to 15th June
- **Planting pattern:** 90 x 30 cm
- **Nutrient management:**
 - G. Cot: 40 kg N. (50 % as basal and 50% as at 45 to 50 days after sowing)
 - V – 797 and CJ – 73: 25 kg N + 25 kg P2O5. All basal.
- **Pest management**
 - Summer ploughing
 - Avoid delayed sowings
 - Use of certified seeds
 - Seed treatment with Captan or Thiram @ 2-3 g/kg seed
 - Destruction of weeds
 - Intercropping with blackgram, soybean, groundnut, setaria, maize, cowpea at two rows for every ten rows of cotton
 - Trap cropping with Okra (1:10), castor, marigold
 - Use of egg parasitoids *Trichogramma* sp.@ 1.5 lakh/ha
 - Spray H-NPV @ 250 LE/ha
 - Use of Neem oil 5%
 - Spray of Quinolophos @2 l/ha or Chloripyriphos @ 2 l/ha
 - Angular leaf spot / arm: Delint the seed with sulphuric acid; spray Agrimycin-10 or Pausamycin @ 75 g/ha+ Copper oxychloride @ 1.87 kg/ha
 - Weeding at 30 days after semi and of 60 days after sowing

Ahmedabad, Surendranagar

- **Varieties:** G.Cot-10, G.Cot-13, G.Cot-15, G.Cot-18, G.Cot-21, V-797, G.Cot-H-8
- **Seed rate:** 12-15 kg/ha
- **Planting pattern:** 90 x 30 cm
- **Nutrient management:**
- (G-Cot-10) 40 kg N/ha in 2 splits half as basal + half as 45 – 50 days after sowing
- 25 kg N + 25 kg P₂O₅ /ha, All basal, (V-797)
- **Pest management:**
- Weed management (mechanical)
 - Hoe for harrowing at 15, 30, 45, 60 Days after sowing
 - Sickle for Hand weeding at 15, 30, 45, 60 Days after sowing
- Weed management (chemical)
 - Fluchloralin / Diuron @ 1.0 kg/ha or 0.7750 kg/ha in 600 liter of water as Pre-emergence
- Disease management
 - Angular leaf spot / arm: Delint the seed with sulphuric acid ; spray Agrimycin-100 or Pausamycin @ 75 g/ha+ copper oxychloride @ 1.87 kg/ha

Suitable cropping systems

Ahmedabad, Surendranagar

- Cotton (Pusa falguni) (paired rows) + greengram (G-2)

Baroda, Bharuch, Mehasana

- Cotton + groundnut

Farm implements/ tools

Ahmedabad, Surendranagar

- For multipurpose tool bar, seed-cum-fertilizer drilling attachment (manually metered) is recommended to carry out three operations i.e. fertilizer -drilling, seed drilling and covering at a time for the farmers of North Saurashtra Agroclimatic Zone

Baroda, Bharuch

- Two bowl seed cum fertilizer drill

Mehasana

- For multipurpose tool bar, seed-cum-fertilizer drilling attachment (manually metered) is recommended to carry out three operations i.e. fertilizer drilling, seed drilling and covering at a time for the farmers of north Saurashtra agroclimatic zone
- Two bowl seed cum fertilizer drill

Alternate farming systems

Ahmedabad, Surendranagar

- Alley cropping: Subabul (paired row) + Sorghum (5-6); Subabul + Groundnut; Perennial Pigeonpea (alleys) + groundnut (GG-2)
- Fodder/ green biomass: On sloppy fallow lands, grow *Dicanthium annulatum*, *Dichrostachys cinerea*, *Albizzia lebbeck*, *Leucaena leucocephala*, *Albizzia lebbeck*, *Pongamia pinnata*

- Fruit: Custard apple Mango, Pomegranate, Phalsa, Fig, Jamun, Tamarind
- Medicinal/ Aromatic Plants: *Plantago ovata*, *Cassia angustifolia*, *Liquorice*.
- Vegetables: Cowpea, Clusterbean, Brinjal, Okra, Long melon, Drumstick.
- Animal component: Female buffaloes, Cows, Male cattle, Sheep, Goat, Poultry

Baroda, Bharuch

- Fodder/ green biomass: *Dichrostachys cineraria*, *Albizia lebbeck*, *Leucaena*, *Pongamia pinnata*
- On slopy fallow lands with shallow soils – *Dicanthium annulatum*; 16 rows of groundnut (GG-2) in alleys of perennial pigeonpea (ICPL-185); 16 rows of groundnut (GG-2) in alleys of subabul (Hawai gaint)
- Fruit: Custard apple, mango, pomegranate phalsa, fig, jamun, tamarind
- Medicinal/ Aromatic Plants: *Plantago ovata*, *Cassia angustifolia*
- Vegetables: Cowpea, cluster bean, brinjal, okra, long melon, drumstick.
- Animal Component: Female/ male cattle, female buffaloes, sheep, goat

Mehasana

- Alley cropping: Subabul (paired row) + sorghum (5-6), Subabul + groundnut, Perennial pigeonpea (alleys) + groundnut (GG-2), Fodder/ green biomass: On sloppy fallow lands, grow *Dicanthium annulatum*, *Dichrostachys cineraria*, *Albizia lebbeck*, *Leucaena leucocephala*, *Pongamia pinnata*
- Fruit: Custard apple, mango, pomegranate phalsa, fig, jamun, tamarind
- Medicinal/ Aromatic Plants: *Plantago ovata*, *Cassia angustifolia*, *Liquorice*.
- Vegetables: Cowpea, cluster bean, brinjal, okra, long melon, drum stick.
- Animal component: Female buffaloes, cows, male cattle, sheep, goat, poultry

Contingent planning

Ahmedabad, Surendranagar

Delay in monsoon by

- 15th July to 31st July:
 - Grow erect groundnut (GG-2, GG-5, GG-7), Sesame (G-Sesame-1, G-Sesame-2), castor (GAUCH-1), hybrid pearl millet (GHB-235, GHB-316, GHB-558), greengram (K-851, GM-4), blackgram (T-9, TPU-4), pigeonpea (ICPL-87, GT-100)
- 1st August to 14th August:
 - Grow pulses blackgram (T-9, TPU-4), forage maize/ sorghum (Gundri, GFS-5), castor (GAUCH-1, GC-2) and Sesame (Purva-1)
- 15th August to 31st August:
 - Grow forage maize/ sorghum (Gundri, GFS-5), sesame (Purva-1)

Drought spell after normal sowing

- 1-2 weeks after sowing:
 - Resowing of early duration varieties or alternate crops should be recommended as under, if sufficient rainfall is received. Hybrid pearl millet (GHB-235, GHB-316, GHB-558), sorghum (GJ-39, J-41), sesame (G-Sesame-1, G-Sesame-2) and castor (GAUCH-1, GC-2), blackgram (T-9, TPU-4)
- 3-5 weeks after sowing:
 - Agricultural operations like interculturing, weeding, hoeing and mulching may be taken up, if drought spell prolongs for two weeks or more weeks. The ratooning of sorghum may be done and top dressing of fertilizer should be suggested if sufficient rainfall after 3-5 weeks dry spell

Early withdrawal of monsoon

- Give life saving irrigation
- Minimize moisture losses through complete removal of weeds
- Perform interculturing to conserve soil moisture
- Harvest the crop according to maturity of crop duration
- Thin the plant population

Satisfactory late rains during September - October

- Relay cropping of castor, sunflower, sesame (Purva-1) and fodder sorghum
- Second crops like rapeseed mustard and chickpea could be taken
- Ratooning of sorghum

Baroda, Bharuch, Mehasana

Delay in monsoon by

- **15th July to 31st July:**
 - Grow erect groundnut (GG-2, GG-5, GG-7), sesame (G-Til-1, G-Til-2), castor (GAUCH-1), hybrid pearl millet (GHB-235, GHB-316, GHB-558), greengram (K-851, GM-4), blackgram (T-9, TPU-4), pigeonpea (ICPL-87, GT-100)
- **1st August to 14th August:**
 - Grow pulses blackgram (T-9, TPU-4), forage maize / sorghum (Gundri, GFS-5), castor (GAUCH-1, GC-2) and sesame (Purva-1)
- **15th August to 31st August:**
 - Grow forage maize/ sorghum (Gundri, GFS-5), sesame (Purva-1)

Drought spell after normal sowing

- 1-2 weeks after sowing:
 - Resowing of early duration varieties or alternate crops should be recommended as under, if sufficient rainfall is received. Hybrid pearl millet (GHB-235, GHB-316, GHB-558), sorghum (GJ-39, J-41), sesame (G-Til-1, G-Til-2) and castor (GAUCH-1, GC-2), blackgram (T-9, TPU-4)
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Early withdrawal of monsoon

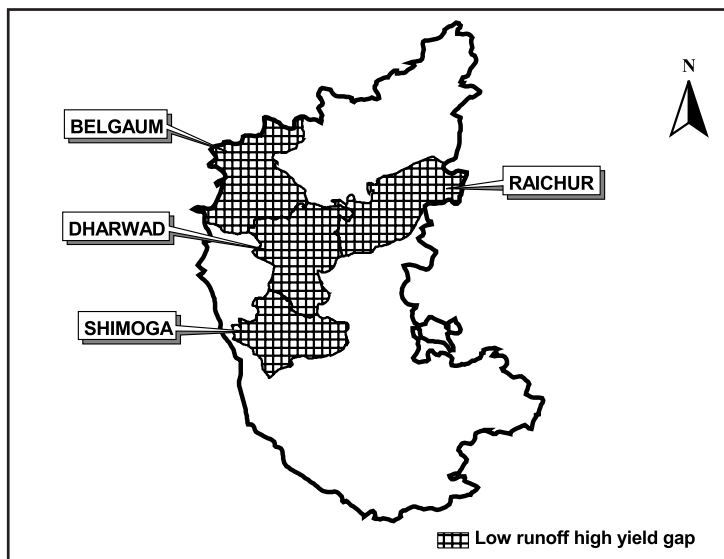
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- Harvest the crop according to maturity of crop duration
- Thin the plant population

Satisfactory late rains during September - October

- Relay cropping of castor, sunflower, sesame (Purva-1) and fodder sorghum
- Second crops like rapeseed mustard and chickpea could be taken
- Ratooning of sorghum

Karnataka

In Karnataka there are four districts viz. Belgaum, Dharwad, Raichur and Shimoga under low runoff and high yield gap region.



District	Region
Belgaum	Low runoff and High yield gap
Dharwad	
Raichur	
Shimoga	

Agro-ecological setting

Belgaum

- **Climate:** Hot dry sub humid
- **Physiography:** Western Karnataka Plateau
- **Soils:** Shallow and medium loamy and clayey black soils and deep clayey black soils (Vertic Inceptisols– 70%; Vertisols – 30%)
- **Annual rainfall:** 1551 mm
- **Potential evapotranspiration:** 1482 mm
- **Moisture availability period:** 150 – 180 days

Dharwad

- **Climate:** Hot dry sub humid
- **Physiography:** Western Karnataka Plateau
- **Soils:** Shallow and medium loamy and clayey black soils and deep clayey black soils (Vertic Inceptisols– 70%; Vertisols – 30%)
- **Annual rainfall:** 813 mm

- **Potential evapotranspiration:** 1665 mm
- **Moisture availability period:** 150 – 180 days

Raichur

- **Climate:** Hot arid
- **Physiography:** North Karnataka Plateau
- **Soils:** Deep loamy and clayey mixed red and black soils (Vertisols – 60%; Vertic Inceptisols– 40%)
- **Annual rainfall:** 719 mm
- **Potential evapotranspiration:** 1951 mm
- **Moisture availability period:** 60 – 120 days

Shimoga

- **Climate:** Hot moist semi arid /Hot moist sub humid to humid (transitional)
- **Physiography:** Central and South Sahayadris
- **Soils:** Medium to deep red loamy soils,deep loamy to clayey red and lateritic soils (Alfisols– 100%)
- **Annual rainfall:** 1045 mm
- **Potential evapotranspiration:** 1381 mm
- **Moisture availability period:** 120 – 270 days

Soil and water conservation

Belgaum

- Graded bunds
- Zingg terraces
- Compartment bunding
- Broad bed and furrows for black soils
- Ridges and furrows
- Supplemental irrigation
- Suitable surface drainage measures to avoid waterlogging

Dharwad

- Rubbles at 0.3 m vertical interval on contour key lines
- Compartment bunding, ridges and furrows, contour cultivation
- Planting Khus grass and subabul in paired rows at vertical interval of 0.3 m
- Bund stabilization through *stylosanthes spp*
- Bund planting with neem, sissou and tamarind
- A farm pond of 150 m³ capacity for every one ha catchment area to harvest excess runoff in medium to deep black soils

Raichur

- Supplemental irrigation with harvested water
- Emphasis be on farmer oriented soil conservation measures like *in-situ* conservation measures

- Plant sunhemp in *rabi* areas
- Rubbles at 0.3 m vertical interval on contour key lines
- Compartment bunding, ridges and furrows, contour cultivation
- Planting Khus grass and subabul in paired rows at vertical interval of 0.3 m
- Bund stabilization through *stylosanthes spp*
- Bund planting with neem, sissou and tamarind
- A farm pond of 150 m³ capacity for every one hectare catchment area to harvest excess runoff in medium to deep black soils

Shimoga

- Sowing across the slope and ridging later contour farming (cultivation and sowing along contour)
- Compartment bunds

Crop management

Belgaum, Dharwad, Raichur, Shimoga

- **Varieties:** Suyodhar
- **Seed rate:** Varieties: 10 - 12 kg/ha; Hybrids: 3.5 kg/ha
- **Planting pattern:** 60 x 30 cm
- Nutrient management:
 - 90 kg N + 45 kg P₂O₅ + 45 kg K₂O + 10-15 t FYM/ ha. Entire N, P and K at sowing
 - 100 kg + 50 kg P₂O₅ + 50 kg K₂O + 10-15 t FYM/ ha. Entire N, P and K at sowing
- **Pest management:**
 - Summer ploughing
 - Avoid delayed sowings
 - Use of certified seeds
 - Seed treatment with Captan or Thiram @ 2-3 g/kg seed
 - Destruction of weeds
 - Intercropping with blackgram, soybean, groundnut, setaria, maize, cowpea at two rows for every ten rows of cotton
 - Trap cropping with Okra (1:10), castor, marigold,
 - Use of egg parasitoids *Trichogramma sp.*@ 1.5 lakh/ha
 - Spray H-NPV @ 250 LE/ha
 - Use of Neem oil 5%
 - Spray of Quinolphos @2 l/ha or Chloripyriphos @ 2 l/ha
 - Angular leaf spot / arm: Delint the seed with sulphuric acid; spray Agrimycin-10 or Pausamycin @ 75 g/ha+ Copperoxychloride @ 1.87 kg/ha
 - Weeding at 30 days after semi and of 60 days after sowing
 - Fluchloralin @ 1.0 kg a.i./ha or Pendamethalin@1.5 kg a.i./ha Preplanting application with one interculture 35 days after sowing
- **Some other important practices:**
 - Sowing in first fortnight of August - medium and deep black soils
 - Seed treatment of with Azospirillan or Azotobactor

Suitable cropping systems

Belgaum, Dharwad, Raichur, Shimoga

- Cotton + blackgram
- Cotton + setaria (1:1)
- Cotton + greengram
- Groundnut + cotton (2:1)
- Chilli – Onion – Cotton (Jayadhar)

Farm implements/ tools

Belgaum, Shimoga

- Ferti - cum - seed drill

Dharwad

- Seed - cum - fertilizer drill
- Bed former
- Bullock drawn two-row wheeled multipurpose tool carrier

Raichur

- Seed cum fertilizer drill
- Bed former
- Bullock drawn two wheeled multipurpose carrier

Alternate farming systems

Belgaum, Dharwad, Raichur

- Agave (*Agave sisolana* with 10,000 plants /ha) intercropped with subabul. Cutting of agave leaves once in a year for fibre extraction with retaining top ten leaves
- Silviculture
 - Shallow black soils: *Cassuarina*, *Dalbergia sissoo*, *Hardwickia binata*, *Acacia nilotica*, *Prosopis cineraria*
 - Marginal land: *Dalbergia sissoo*, neem, *Acacia nilotica*, Subabul
- Alley cropping: Subabul/ cassuarina + *Kharif* crops
- Agro horti system:
 - Ber (umran) + curry leaf, Vegetable – curry leaf
 - Ber (umran) – safflower + chickpea
 - Ber/ custard apple/ pomegranate/ amla + *kharif* (spreading) crops
- Horticulture: Mango plants in leveled portion of zing conservation terrace
- Fodder/ green biomass: *Dalbergia sissoo*, *Glyricidia*, *Albizzia lebbeck*, *Hardwickia binata*, *Cassia siamea*, *Azadirachta indica*
- Fruit: Mango, pomegranate, sapota, ber, jamun, tamarind
- Medicinal/ Aromatic Plants: *Cassia angustifolia*, *Catharanthus roseus*, *Palma rosa*, *Vetiveria zizanioides*, *Rose*, *Geranium*

- Vegetables: Onion, brinjal, chillies, cowpea, cucumber, cluster bean, drumstick.
- Animal component: Male/ female cattle, female buffaloes, sheep, goat, poultry

Shimoga

- Fodder/ green biomass: *Hardwickia binata*, *Albizia lebbeck*, *Leucaena leucocephala*, *Dalbergia*, *sissoo*, *Azadirachta indica*
- Fruit: Mango, sapota, pomegranate, fig, guava
- Medicinal/ Aromatic Plants: *Vetiveria zizanioides*, *Palma rosa*, *Cassia angustifolia*, *Catharanthus roseus*
- Vegetables: Tomato, chillies, brinjal, amaranthus, bittergourd
- Animal Component: Female cattle, male cattle, female buffaloes, goat, sheep, poultry

Contingent crop planning

Belgaum, Dharwad, Raichur

Normal onset of monsoon favourable for kharif crops

- Take up sowing of the following crops in June in light soils. Groundnut (erect and spreading), pearl millet, pigeonpea, *kharif* sorghum, setaria, hybrid sorghum and other crop mixtures like *kharif* sorghum + pigeonpea (2:1), groundnut + pigeonpea (4:2), setaria + pigeonpea (2:1) and pearl millet + pigeonpea (2:1). Similarly, pulse crops in light and retentive soils may be taken up.
- In *rabi* areas, i.e., medium deep black soils, sow greengram, blackgram, cucumber as a first crop to be followed by *rabi* sorghum / sunflower/chickpea/safflower/wheat.
- When the land is kept fallow (deep black soils) for *rabi* crops, have Compartment bunds having 1 per cent slope, scooping where the land slope is 1 to 2 per cent, ridges and furrows or tied ridges for better soil and moisture conservation. Take up harrowings after each rain which helps in controlling weeds and conserving soil moisture.
- Sow sunhemp as green manuring crop in medium to deep black soils prior to *rabi* crops.

Normal onset of monsoon but dry spells soon after germination

- Give protective irrigation for the crops sown wherever possible.
- Ratoon pearl millet, sorghum for rejuvenation after rains.
- For crops like groundnut, take up urea spray (2% solution) immediately after rains for quick revival.
- When the sown crops completely wither, plant setaria, dolichos, horsegram, matki, cowpea and sunflower soon after revival of rains.

No normal rains in June but onset of rains in July

- Sow groundnut (spreading), hybrid pearl millet, sunflower and setaria in *kharif* areas.
- Sow pure pigeonpea/ cowpea/ horsegram in light soils.
- In *rabi* areas don't sow greengram since it will delay *rabi* sowing.
- Have repeated harrowings to remove weeds in *rabi* areas.

Normal rains in July/August

- Complete sowing dryland cotton before the middle of August. Grow Herbaceous cottons in place of Hirsutams. Early sowing of cotton is advantageous.
- Sunflower, pigeonpea, and setaria should be sown in light soils and pigeonpea in medium to deep black soils.

- In light textured soils in Hadagali, Koppal, Muddebihal, Raibag, and Athani castor may be sown. Plant castor on contour bunds also. In medium to deep black soils also take up castor sowing.
- Relay cotton in groundnut in medium black soils.

Normal rains in September

- Complete sowing of *rabi* sorghum by middle of September in medium black soils of northern taluks of Bijapur district. In the remaining taluks viz., Bagalkot, Hungund, and Mudhol, complete *rabi* sorghum sowing by first week of October. Early sowing of *rabi* sorghum in other districts is preferred. Maximum yields of *rabi* sorghum are obtained by sowing in September only.
- Sow sunflower before 10th of September.
- Sow safflower as a sole crop before the end of September. Early sowing is more beneficial.
- Complete sowing of Bhagya/Laxmi cotton before 15th September.
- If normal rains are not received during September take up dry seeding of sunflower, *Rabi* sorghum, Chickpea with 1 1/2 times the normal seed rate relatively at depth without applying chemical fertilizers. Fertilizers may be applied at appropriate growth stage having optimum moisture condition.

Sowing in October

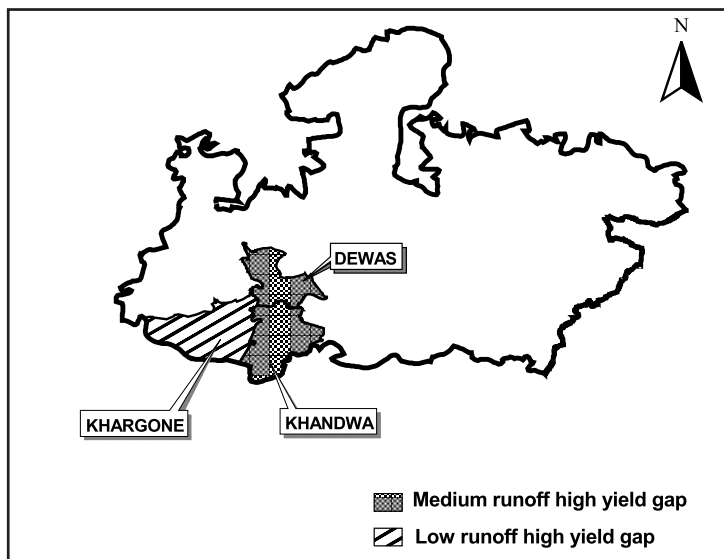
- Continue the sowing *rabi* sorghum till October 15th with 50 per cent recommended level of fertilizer.
- Follow cropping of *rabi* sorghum + chickpea in 2:1 row proportion.
- Sow *rabi* sorghum and chickpea as mixed crops (random mixing).
- Increase the area under safflower.
- Sow chickpea and safflower in 4:2 or 3:1 row proportions for higher returns.
- Top dress *rabi* sorghum with 10-15 kg N/ha if adequate moisture is available in the soil.

Early stoppage of rains towards the end of season

- Thin out the population of *rabi* sorghum by blading every third row or alternate row within 40 days of sowing.
- In mixed crops of *rabi* sorghum and safflower, uproot *rabi* sorghum component.
- Close soil cracks by repeated interculturing.
- Provide supplemental irrigation through farm ponds or other sources. By providing one or two supplemental irrigation(s) to *rabi* sorghum, safflower and chickpea, yields could be increased by 50 to 60 per cent.

MADHYA PRADESH

In Madhya Pradesh there are two districts viz. Dewas and Khandwa under medium runoff and high yield gap region and one district viz. Khargone under low runoff and high yield gap region,



District	Region
Dewas Khandwa	Medium runoff and high yield gap

Agro-ecological setting

Dewas

- **Climate:** Hot moist / dry sub humid
- **Physiography:** Malwa plateau
- **Soils:** Deep clayey black soils and shallow black soils, medium (Vertic Inceptisols– 100%)
- **Annual rainfall:** 1079 mm
- **Potential evapotranspiration:** 1707 mm
- **Moisture availability period:** 120–150 / 150-180 days

Khandwa

- **Climate:** Hot moist semi arid / dry sub humid
- **Physiography:** Malwa plateau
- **Soils:** Deep clayey black soils and shallow black soils, (Veric Inceptisols - 100%)
- Annual rainfall: 961 mm
- Potential evapotranspiration: 1728 mm
- Moisture availability period: 120–150 / 150-180 days

Soil and water conservation

Khandwa, Dewas

- Straighten the gullied portion in the farmers' fields through earth moving machinery to reduce the length of gully allowing safe passage for the run off water. It brings additional area under cultivation through reclamation process.
- Construct percolation tank for increasing ground water recharge and enhancing ground water storage to provide extra irrigation to the crops.
- Use gabion as an inlet and outlet of water harvesting tank without any structural failure to trap silt on the upstream sit to increase life of water storage bodies.
- Construct water harvesting tank to retain the excess run off from the water shed area to use stored water for irrigation purpose.
- Silpaulin (a plastic material) of 90 – 120 gsm has been found effective lining material for farm ponds used for water harvesting purposes.
- Use vegetative barriers to strengthen the mechanical bunds at suitable vertical intervals in order to reduce run off in associated soil losses from the cultivated fields.
- Develop a sort of terracing (raised and sunken beds) break the continuity of undulating slope to reduce the chances of degrading cultivated fields in to gullied one.
- Ensure drainage line treatment for providing safe disposal of excess run off and providing more opportunity time in order to reduce erosive velocity.
- Mould board plough, used for deep tillage to increase the productivity of kharif crops and enhance sowing of *rabi* crops through better moisture conservation and eradication of infested weeds.
- Graded bunds alone and / or along with vegetative barriers at vertical intervals of 50 cm proves most effective in controlling soil erosion and nutrient losses on soils having slope up to 2 per cent.
- Off-season shallow tillage is important not only in controlling the weeds but also in helping entry of rain water.
- Provide *insitu* soil mulch by operating bullock drawn dora to fill up the cracks, to conserve the soil moisture and to achieve weed control. Straw as mulch @ 4-5 t/ha in between the rows of crop plants to minimize evaporative losses, moisture conservation and to increase moisture efficiency in *rabi* crops.

Crop management

Khandwa

- **Varieties:** LRA 5166, NHH-44, Ankur-651
- **Seed rate:** Varieties: 10 kg/ha; Hybrids: 3.5 kg/ha
- **Planting pattern:**
 - Varieties- 60 x 30 cm
 - Hybrids: 90 x 60 cm
- **Nutrient management:** 100 kg N (in two splits i.e., half at first square formation and half at peak flowering) + 50 kg P₂O₅ + 50 kg K₂O + 10-15 t FYM/ ha. Entire P and K at sowing
- **Pest management:**
 - Summer ploughing
 - Avoid delayed sowings
 - Use of certified seeds

- Seed treatment with Captan or Thiram @ 2-3 g/kg seed
- Destruction of weeds
- Intercropping with blackgram, soybean, groundnut, setaria, maize, cowpea at two rows for every ten rows of cotton
- Trap cropping with Okra (1:10), castor, marigold,
- Use of egg parasitoids *Trichogramma* sp. @ 1.5 lakh/ha
- Spray H-NPV @ 250 LE/ha
- Use of Neem oil 5%
- Spray of Quinolphos @2 l/ha or Chloripyriphos @ 2 l/ha
- Angular leaf spot / arm: Delint the seed with sulphuric acid; spray Agrimycin-10 or Pausamycin @ 75 g/ha+ copper oxychloride @ 1.87 kg/ha

Farm implements/ tools

Khandwa, Dewas

Suitable implements for seedbed preparations

- Meston Plough
- Iron Bakhar

Suitable implements for sowing operations

- Mahakal Dufan
- Mahakal Tifan
- Sarta attachment for intercropping

Suitable implements/ tools for interculture operations

- Hand dora (small blade harrow)
- Bullock drawn dora (small blade harrow with wooden beam)
- Indore ridger

Alternate farming systems

Khandwa, Dewas

- Fodder/ green biomass: *Dichrostachys cineraria*, *Albizia amara*, *Faidherbia albida*, *Hardwickia binata*, *Cassia*, *Leucaena leucocephala*, *Albizia lebbeck*,
- Fruit: Ber, pomegranate, mango, fig, tamarind
- Medicinal/ Aromatic Plants: *Withamnia somnifera*, *Rauvolfia serpentina*, *Vetiveria zizanioides*, *Palma rosa*, *Liquorice*.
- Vegetables: Chillies, okra, watermelon, cowpea, cluster bean, amaranth, round melon.
- Animal component: Male/ female cattle, female buffaloes, sheep, goat, dairy

Contingent planning

Khandwa, Dewas

- If monsoon is delayed or there is failure of timely sown crops due to intermittent droughts then for delayed sowing improved crops and their varieties may be chosen for planting, as given below:

- **15th to 31st July**
 - Maize - (short duration varieties like Navjot, sathi, etc.).
 - Pigeonpea - (under deep soils preferred varieties ICPL 151, T-21, Kh-2, ICPL 87, ICPL 88039 etc.).
 - Sunflower – Morden, Surya, Manjira and any other hybrids
 - Sesame – Bhadeli, TKG 22, TKG 37 etc.
 - Cowpea – Pusa Komal and Pusa Baisakhi.
 - Castor – GCH 4, Kranthi.
 - Fodder crops – *Sorghum sudanensis*, Maize- African tall, Dinanath grass and pearl millet.
- **1st to 15th August**
 - Sunflower – Morden, Surya, Manjira and any of the hybrids.
 - Sesame – Bhadeli, TKG 22, TKG 37 etc.
 - Cowpea – Pusa Komal and Pusa Baisakhi.
 - Rajgira (Amaranthus)- Co-1 and Co-2.
 - Fodder crops – *Sorghum Sudanensis*, Maize- African tall, Dinanath grass and Pearl millet.
- **15th to 31st August**
 - Safflower – JSF-1, JSF- 7 (spineless), JSF-73, Sharda
 - Sunflower – Morden, Surya and Manjira
 - Sesame – Bhadeli, TKG 22, and RT-46
 - Rajgira – Co-1 and Co-2.
 - Castor – GCH 4, Kranthi.
 - Fodder crops – Barley, oats, Maize- African tall

District	Region
Khargone	Low runoff and High yield gap

Agro-ecological setting

- **Climate:** Hot moist semi arid
- **Physiography:** Western Malwa Plateau
- **Soils:** Deep clayey black soils and shallow black soils, medium and deep clayey black soils, shallow loamy black soils (Vertic Inceptisols – 100%)
- **Annual rainfall:** 888 mm
- **Potential evapotranspiration:** 1792 mm
- **Moisture availability period:** 120 – 180 days

Soil and water conservation

- Straighten the gullied portion in the farmers' fields through earth moving machinery to reduce the length of gully allowing safe passage for the run off water. It brings additional area under cultivation through reclamation process.
- Construct percolation tank for increasing ground water recharge and enhancing ground water storage to provide extra irrigation to the crops.
- Use gabion as an inlet and outlet of water harvesting tank without any structural failure to trap silt on the upstream sit to increase life of water storage bodies.

- Construct water harvesting tank to retain the excess run off from the water shed area to use stored water for irrigation purpose.
- Silpaulin (a plastic material) of 90 – 120 gsm has been found effective lining material for farm ponds used for water harvesting purposes.
- Use vegetative barriers to strengthen the mechanical bunds at suitable vertical intervals in order to reduce run off in associated soil losses from the cultivated fields.
- Develop a sort of terracing (raised and sunken beds) break the continuity of undulating slope to reduce the chances of degrading cultivated fields into gullied one.
- Ensure drainage line treatment for providing safe disposal of excess run off and providing more opportunity time in order to reduce erosive velocity.
- Mould board plough, used for deep tillage to increase the productivity of *kharif* crops and enhance sowing of *rabi* crops through better moisture conservation and eradication of infested weeds.
- Graded bunds alone and / or along with vegetative barriers at vertical intervals of 50 cm are most effective in controlling soil erosion and nutrient losses on soils having slope up to 2 per cent.
- Off-season shallow tillage is important not only in controlling weeds but also in helping entry of rain water.
- Provide *insitu soil* mulch by operating bullock drawn dora to fill up the cracks, to conserve soil moisture and to achieve weed control. Straw mulch @ 4-5 t/ha in between the rows of crop plants to minimize evaporative losses, moisture conservation and to increase moisture efficiency in *rabi* crops.

Crop management

- **Varieties:** LRA 5166, NHH-44, Ankur-651
- **Seed rate:** Varieties: 10 kg/ha; Hybrids: 3.5 kg/ha
- **Planting pattern:**
 - Varieties- 60 x 30 cm
 - Hybrids: 90 x 60 cm
- **Nutrient management:** 100 kg N (in two splits i.e., half at first square formation and half at peak flowering) + 50 kg P₂O₅ + 50 kg K₂O + 10-15 t FYM/ ha. Entire P and K at sowing
- **Pest management:**
 - Summer ploughing
 - Avoid delayed sowings
 - Use of certified seeds
 - Seed treatment with Captan or Thiram @ 2-3 g/kg seed
 - Destruction of weeds
 - Intercropping with blackgram, soybean, groundnut, setaria, maize, cowpea at two rows for every ten rows of cotton
 - Trap cropping with Okra (1:10), castor, marigold
 - Use of egg parasitoids *Trichogramma* sp. @ 1.5 lakh/ha
 - Spray H-NPV @ 250 LE/ha
 - Use of Neem oil 5%
 - Spray of Quinolphos @ 2 l/ha or Chloripyriphos @ 2 l/ha
 - Angular leaf spot / arm: Delint the seed with sulphuric acid; spray Agrimycin-10 or Pausamycin @ 75 g/ha+ copper oxychloride @ 1.87 kg/ha

Farm implements/ tools

Suitable implements for seedbed preparations

- Meston Plough

- Iron *Bakhar*

Suitable implements for sowing operations

- Mahakal Dufan
- Mahakal Tifan and
- Sarta attachment for intercropping

Suitable implements/ tools for interculture operations

- Hand dora (small blade harrow)
- Bullock drawn dora (small blade harrow with wooden beam)
- Indore ridger

Alternate farming systems

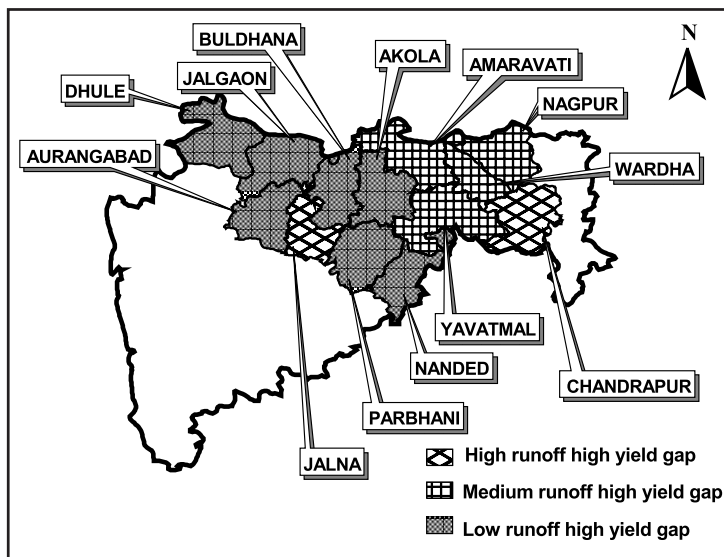
- Fodder/ green biomass: *Dichrostachys cineraria*, *Albizia amara*, *Faidherbia albida*, *Hardwickia binata*, *Cassia*, *Leucaena leucocephala*, *Albizia lebbeck*
- Fruit: Ber, pomegranate, mango, fig, tamarind
- Medicinal/ Aromatic Plants: *Withamnia somnifera*, *Rauvolfia serpentina*, *Vetiveria zizanioides*, *Palma rosa*
- Vegetables: Chillies, okra, watermelon, cowpea, cluster bean, amaranthus, round melon
- Animal component: Male/ female cattle, female buffaloes, sheep, goat

Contingent planning

- If monsoon is delayed or there is a failure of timely sown crops due to intermittent droughts then for delayed sowing improved crops and their varieties may be chosen for planting, as given below:
- **15th to 31st July**
 - Maize – (short duration varieties like Navjot, Sathi)
 - Pigeonpea – (under deep soils, preferred varieties are ICPL 151, T-21, Kh-2, ICPL 87, ICPL 88039)
 - Sunflower – Morden, Surya, Manjira
 - Sesame – Bhadeli, TKG 22, TKG 37
 - Cowpea – Pusa Komal and Pusa Baisakhi
 - Castor – GCH 4, Kranthi
- **1st to 15th August**
 - Fodder crops – *Sorghum sudanensis*, maize- African tall, *Dinanath* grass and pearl millet etc.
 - Sunflower – Morden, Surya, Manjira and any of the hybrids
- **15th to 31st August**
 - Sesame – Bhadeli, TKG 22, TKG 37
 - Cowpea – Pusa Komal and Pusa Baisakhi
 - Rajgira – (Amaranthus) – Co-1, Co-2
 - Castor – GCH 4, Kranthi
 - Fodder crops – *Sorghum sudanensis*, maize- African tall, *Dinanath* grass and pearl millet etc.
 - Safflower – JSF-1, JSF- 7 (spineless), JSF-73, Sharda
 - Sunflower – Morden, surya and manjira
 - Sesame – Bhadeli, TKG 22, and RT-46
 - Rajgira –Co-1 and Co-2
 - Fodder crops – Barley, oats, maize – African tall

MAHARASHTRA

In Maharashtra there are seven districts viz., Akola, Aurangabad, Buldana, Dhule, Jalgaon, Nanded and Parbhani under low runoff and high yield gap region, four districts viz., Amravati, Nagpur, Wardha and Yavatmal under medium runoff and high yield gap; and two districts viz., Chandrapur and Jalna under high runoff and high yield gap region.



District	Region
Akola	Low runoff and High yield gap
Aurangabad	
Buldana	
Dhule	
Jalgaon	
Nanded	
Parbhani	
Amravati	Medium runoff high yield gap
Nagpur	
Wardha	
YAVATMAL	
CHANDRAPUR	High runoff high yield gap
JALNA	

Agro-ecological setting

Akola

- **Climate:** Hot moist semi arid
- **Physiography:** Eastern Maharashtra Plateau
- **Soils:** Medium and deep clayey black soils and shallow loamy to clayey black soils (Vertic Inceptisols– 60%; Vertisols – 40%)
- **Annual rainfall:** 878 mm
- **Potential evapotranspiration:** 1730 mm
- **Moisture availability period:** 120 – 150 days

Aurangabad

- **Climate:** Hot semi arid
- **Physiography:** Central Maharashtra Plateau

- **Soils:** Shallow and medium loamy and medium and deep clayey black soils (Vertic Inceptisols- 80%; Vertisols- 20%)
- **Annual rainfall:** 786 mm
- **Potential evapotranspiration:** 1774 mm
- **Moisture availability period:** 120 – 150 days

Buldana

- **Climate:** Hot moist semi arid
- **Physiography:** Eastern Maharashtra Plateau
- **Soils:** Medium and deep clayey black soils and shallow loamy to clayey black soils (Vertic Inceptisols– 75%; Vertisols – 25%)
- **Annual rainfall:** 901 mm
- **Potential evapotranspiration:** 1648 mm
- **Moisture availability period:** 120 – 150 days

Dhule

- **Climate:** Hot semi arid
- **Physiography:** Western Maharashtra Plateau
- **Soils:** Shallow and medium loamy and medium and deep clayey black soils. Shallow loamy to clayey black soils (Vertic Inceptisols– 65%; Vertisols – 35%)
- **Annual rainfall:** 738 mm
- **Potential evapotranspiration:** 1713 mm
- **Moisture availability period:** 120 – 150 days

Jalgaon

- **Climate:** Hot moist semi arid
- **Physiography:** Eastern/ Western Maharashtra Plateau
- **Soils:** Shallow and medium loamy and medium and deep clayey black soils, shallow loamy to clayey black soils (Vertic Inceptisols- 65%; Vertisols – 35%)
- **Annual rainfall:** 841 mm
- **Potential evapotranspiration:** 1912 mm
- **Moisture availability period:** 120 – 150 days

Nanded

- **Climate:** Hot semi arid
- **Physiography:** Central Maharashtra Plateau
- **Soils:** Shallow and medium loamy, and medium and deep clayey black soils (Vertic Inceptisols 60%; Vertisols – 40%)
- **Annual rainfall:** 915 mm

- **Potential evapotranspiration:** 1789 mm
- **Moisture availability period:** 120 – 150 days

Parbhani

- **Climate:** Hot semi arid
- **Physiography:** Central Maharashtra Plateau
- **Soils:** Shallow and medium loamy, and medium and deep clayey black soils (Vertic Inceptisols – 75%; Vertisols – 25%)
- **Annual rainfall:** 905 mm
- **Potential evapotranspiration:** 1769 mm
- Moisture availability period: 120 - 150 days

Soil and water conservation

Nanded

- Contour bunds
- Graded bunds for high rainfall areas
- Suitable surface drainage measures in high rainfall and deep black soils to avoid waterlogging
- Supplemental irrigation in high rainfall areas with harvested water during dry spells
- *In-situ* conservation measures like mulching, conservation furrows, deep tillage
- Compartment bunding and ridges and furrows prior to sowing
- Marvel-8 grass on bunds for protection of bunds
- Contour live bunds of Marvel-8 or *Leucaena*
- *Leucaena* cropping mulch at 3.5 t/ha

Aurangabad, Parbhani, Dhule

- Compartment bunding
- Ridges and furrows prior to sowing
- Marvel – 8 grass on bunds for protection of bunds for protection of bunds
- Contour live bunds of Marvel – 8 or *Leucaena*
- *Leucaena* lopping mulch at 3.5 t/ha

Buldana

- Importance for permanent soil conservation measures
- Water harvesting for raising a successful seed crop may be encouraged
- Suitable for surface drainage measures to avoid water logging
- On slopy land contour cultivation along vegetative hedge of *Vetiver* or *Leucaena* at 0.5 m vertical interval
- Broad bed furrows
- Compartment bunding
- Sowing across the slope

Akola

- On slopy land contour cultivation along vegetative hedge of *Vetiver* or *Leucaena* at 0.5 m vertical interval.
- Broad bed furrows
- Compartment bunding
- Sowing across the slope
- Contour farming (cultivation and sowing along contour)

Jalgaon

- Compartment bunding
- Ridges and furrows
- Graded bunds on clayey soil to drain off excess water
- *In-situ* conservation measures like tillage, mulching, conservation furrows, ridging
- Contour farming

Crop management

Dhule, Nanded

- **Varieties:** LRA 5166, NHH-44, Ankur-651
- **Seed rate:** 10 kg/ha
- **Date of sowing :** 16th to 30th June
- **Planting pattern:** Varieties- 60 x 30 cm; Hybrids: 90 x 60 cm
- **Nutrient management:** 100 kg N (in two splits i.e, half at first square formation and half at peak flowering) + 50 kg P₂O₅ + 50 kg K₂O + 10-15 t FYM/ ha. Entire P and K at sowing
- **Pest management:**
 - Summer ploughing
 - Avoid delayed sowings
 - Use of certified seeds
 - Seed treatment with Captan or Thiram @ 2-3 g/kg seed
 - Destruction of weeds
 - Intercropping with blackgram, soybean, groundnut, setaria, maize, cowpea at two rows for every ten rows of cotton
 - Trap cropping with Okra (1:10), castor, marigold
 - Use of egg parasitoids *Trichogramma* sp.@ 1.5 lakh/ha
 - Spray H-NPV @ 250 LE/ha
 - Use of Neem oil 5%
 - Spray of Quinolphos @2 l/ha or Chloripyriphos @ 2 l/ha
 - Angular leaf spot / arm: Delint the seed with sulphuric acid; spray Agrimycin-10 or Pausamycin @ 75 g/ha+ copper oxychloride @ 1.87 kg/ha
 - Weeding at 30 days after semi and of 60 days after sowing
- **Some other important practices**
 - Sowing in first fortnight of June
 - Seed treatment of with *Azospirillum* or *Azotobactor*

Akola, Aurangabad, Buldhana, Jalgaon, Parbhani

- **Varieties:** LRA 5166, NHH-44, Ankur-651, LRA 5166, PKV Rajat, Anjali, H 4 AkH 4, AKA 5
- **Seed rate:** Varieties: 10 kg/ha; Hybrids: 3.5 kg/ha
- **Date of sowing:** 25th June to 8th July - Akola, Aurangabad, Buldana
- **Date of sowing:** 16th to 30th June - Jalagaon, Parbhani
- **Planting pattern:** Varieties- 60 x 30 cm; Hybrids: 90 x 60 cm
- **Nutrient management:**
 - 60 kg P₂O₅ + 5 0kg K₂O + 10-15 t FYM/ ha.
 - 60-90 kg N/ha – in three splits (1/2 at sowing + 1/4 at squaring + 1/4 at flowering)
 - K – 1/2 to 1/3 of the dose of N.
 - Entire P and K at sowing
 - *Leucaena* loppings @ 4.5 t/ ha + 60 kg N+ 30 kg P₂O₅ / ha
- **Pest management:**
 - Summer ploughing
 - Avoid delayed sowings
 - Use of certified seeds
 - Seed treatment with Captan or Thiram @ 2-3 g/kg seed
 - Destruction of weeds
 - Intercropping with blackgram, soybean, groundnut, setaria, maize, cowpea at two rows for every ten rows of cotton
 - Trap cropping with Okra (1:10), castor, marigold,
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 - Angular leaf spot / arm: Delint the seed with sulphuric acid; spray Agrimycin-10 or Pausamycin @ 75 g/ha+ copper oxychloride @ 1.87 kg/ha
 - Weeding at 30 days after semi and of 60 days after sowing
- **Some other important practices**
 - Sowing in first fortnight of June
 - Seed treatment with *Azospirillum* or *Azotobactor*
 - Sowing: 25 June to 8 July
 - 2 to 3 foliar sprays of 1-2% urea or Diammonium phosphate (DAP) at flowering and 15-20 days later.
 - Cowpea grown as live mulch
 - Two sprays of ploufix (29 pm) at start flowering and at 50% flowering

Suitable cropping systems

Dhule, Nanded

- Cotton + pigeonpea
- Cotton + sorghum
- Akola, Aurangabad, Buldana, Jalgaon, Parbhani

- Cotton + sorghum (two year rotation)
- Cotton + pigeonpea (12:2)
- Cotton + soybean
- Cotton + groundnut
- Cotton + greengram (1:1)
- Cotton + blackgram

Farm implements/ tools

Akola

- Manually operated fertilizer drill: Simple two row tool for top dressing (hand metered)
- Bullock drawn serrated blade for interculture: Two rows, improved blades for intercultivation
- Four row seed cum fertilizer drill for multipurpose tool carrier (NIKART)
- Israeli model of tractor drawn seed drill (PDKV, Akola)

Aurangabad, Buldhana, Parbhani

- Jyothi planter which can sow cotton as well as apply fertilizers (MPKV, Pune)
- Bullock drawn two-row seed cum fertilizer drill
- Bullock drawn Shivaji multipurpose farming machine
- Four row seed cum fertilizer drill for multipurpose tool/carrier (NIKART)

Dhule, Jalgaon, Nanded

- Tractor multicrop planter. Sowing of *rabi* sorghum was done on farmer's field. Minor modifications made in the original design for adoption of the machine in dryland region. Awareness was created amongst the farmers by conducting demonstrations on farmer's field. The farmers were satisfied with operation of this machine. Rs.22800/-
- Bullock drawn Jyoti Planter. The field trials were conducted and the machine is recommended for sowing the crops of dryland region. Rs.7500/-
- Weeders developed by Maharashtra Agro Industries Development Corporation Ltd. (MAIDC). These weeders were tested on farmer's field and identified for weeding and interculturing in row crops. Rs.410/-
- Tractor drawn: single bottom reversible plough. Tested on farmers' field for ploughing and identified for ploughing operations in dryland region as the field operation was effective and economical. Rs 18500/-
- Tractor drawn: double bottom reversible plough. Tested on farmers' field for ploughing and identified for ploughing operations in dryland region as the field operation was effective and economical. Rs.23600/-
- Bund formers were tested and found suitable for Compartment bunding. Rs.1050/-
- Baliram plough. Identified for moisture conservation practices like ridges and furrows and Compartment bunding. Rs.2500/-
- Kopergaon bullock drawn two bowl seed drill. The local made seed drill named "Kopergaon seed drill" is operated on the field for sowing crops like sorghum, pearl millet, pigeonpea etc. and identified for sowing of the crops of dryland region. Rs.9000/-
- A four row seed cum fertilizer drill for multipurpose tool carrier (NIKART)

- Jyothi planter which can sow cotton as well as apply fertilizers (MPKV, Pune)

Alternate farming systems

Nanded, Parbhani

- Agri-Horticultural system - Ber (5x5 m) + mothbean (8 lines) (30x10 cm)
- Silviculture: *Leucaena* + *Marvel* –8
- Alley cropping: Ber (20 m alleys) + pearl millet + pigeonpea for shallow soils
- Fodder: Maize (African Tall), oats (Kent), *Stylosanthes hamata*
- Fodder/ green biomass: *Alianthus excelsa*, *Albizia lebbbeck*, *Dalbergia sissoo*, Neem, *Prosopis cineraria*
- Fruit: Ber, date palm, jamun, fig, phalsa, karonoda
- Medicinal / aromatic plants: *Plantago ovata*, *Cassia angustifolia*, *safed musli*, *Papaver somniferum*
- Vegetables: clusterbean, cowpea, amaranthus, round melon
- Animal component: Female buffalo/ sheep, goat

Aurangabad, Buldana

- Fodder/green biomass: *Stylosanthes* sole and Stylo-marvel pastoral system recorded higher green fodder yield than sole or combination of grasses. *Leucaena leucocephala*, *A.lebbbeck*, *D.sissoo*, *A.indica*, *A.procera*, *Gliricidia*
- Fruit: Ber agro-horticulture system (ber + short duration Legume crop) was found more remunerative than anola and custard apple horticulture system. Pomegranate, ber, mango, sapota, guava, tamarind
- Medicinal & Aromatic Plants: *Solanum viarum*, *Catharanthus roseus*, *Palma rosa*, *Vetiveria zizanooides*, *Ocimum viride*
- Vegetables: Onion, chilli, Brinjal, okra, amaranthus, bottle gourd.
- Animal Component: Female cattle, male cattle, female buffaloes, goat and poultry

Crop planning as per soil genetic layer

Aurangabad, Parbhani

Soil depth (cm)	Available moisture (mm)	Crops to be taken
< 7.5	15-20	Grasses, Agroforestry, Dryland horticulture
7.5 – 22.5	30-35	Grasses, Horsegram, Mothbean, Castor, Agroforestry, Dryland Horticulture, pearl millet + horsegram / mothbean (2:1)
22.5 – 45	40-65	Sunflower, pearl millet, pigeonpea, pearl millet + pigeonpea (2:1), pigeonpea + clusterbean (1:2), castor + clusterbean (1:2), castor + ridge gourd, castor 90x45 cm line sowing of ridge gourd in the castor row at 100 cm spacing.
45 - 60	60-150	Rabi Sorghum, safflower, sunflower & chickpea
> 60	> 150	Rabi sorghum, safflower, sunflower, chickpea and Double cropping.

Akola

- Fodder/ green biomass: *Leucaena Leucocephala*, *Albizia lebbeck*, *Dalbergia sissoo*, *Azadirachta indica*, *Acacia procera*, *Gliricidia*
- Fruit: Pomegranate, ber, mango, sapota, guava, tamarind
- Medicinal/ Aromatic Plants: *Solanum viarum*, *Catharanthus roseus*, *Palma rosa*, *Vetiveria zizanioides*, *Ocimum viride*
- Vegetables: Onion, chilli, brinjal, okra, amaranthus, bottle gourd.
- Animal component: Male/female cattle, female buffaloes, sheep, goat, poultry

Alternate land use system

Aurangabad, Dhule, Jalgaon, Nanded, Parbhani

- Lands < 22.5 cm depth of soil should be cultivated with agroforestry and dryland horticulture including ber, custard apple, amla, wood apple, jambhul etc.
- On light soils Ber cultivation at 20x5 m spatial arrangement associated with pearl millet + pigeonpea (2:1) intercropping within two rows of ber plantation was recommended.
- Silvopastoral system of Subabul + Marvel-8 with cutting of the alternate trees at 7th year onwards for fuel is also recommended.
- For productivity increment in scarcity area the pearl millet + pigeonpea (2:1) intercropping or ber (5x5 m) + mothbean (8 lines) is advocated.

Jalgaon

- Fodder/ green biomass: *Leucaena Leucocephala*, *Albizia lebbeck*, *Dalbergia sissoo*, *Acacia indica*, *Acacia procera*, *Glyricidia*
- Fruit: Pomegranate, ber, mango, sapota, guava, tamarind
- Medicinal and aromatic plants: *Solanum viarum*, *Catharanthus roseus*, *Palma rosa*, *Vetiveria zizanioides*, *Ocimum viride*
- Vegetables: Onion, chilli, brinjal, okra, amaranthus, bottlegourd.
- Animal Component: Male/ female cattle, female buffaloes, sheep, goat, poultry

Dhule

- Silvopasture: *Leucaena* + Marvel –8
- Alley cropping: Ber (20 m alleys) + Pearl millet + Pigeonpea for shallow soils
- Fodder: Maize (African Tall) Oats (Kent), *Stylo hamata*
- Fodder/ green biomass: *Dalbergia sissoo*, *Albizia lebbeck*, *Anogeissus latifolia*, *Sesbania*, *Stylo*, Marvel – 8 grass
- Fruit: Ber, Custard apple, Pomegranate, amla+kharif spreading crops
- Medicinal and aromatic plants: *Catharanthus roseus*, *Palma rosa*, *Vetiveria zizanioides*, *Rose*, *Geranium*
- Vegetables: Onion, tomato, okra, cowpea, cluster bean, drumstick
- Animal Component:

- Cow breeds: Gir, Jersey
- Poultry: White Leghorn
- Rams
- Male/ female cattle, female buffaloes, sheep, goat

Dhule

Alternate land use system:

- Lands < 22.5 cm depth of soil should be cultivated with Agroforestry and dryland horticulture including ber, custard apple, anola, wood apple, jambhul etc.
- On light soils ber cultivation at 20x5 m spatial arrangement associated with pearl millet + pigeonpea (2:1) intercropping within two rows of ber plantation was recommended.
- Silvopastoral system of Subabul + Marvel-8 with cutting of the alternate trees at 7th year onwards for fuel is also recommended.

Contingent planning

Aurangabad, Dhule, Nanded, Parbhani

- Mid season corrections during *kharif* with soil having depth upto 45 cm for the scarcity zone.

Second fortnight of June:

- All *Kharif* crops

First fortnight of July:

- Pearl millet, setaria, groundnut, castor, pigeonpea, horsegram
- Intercropping of pearl millet + pigeonpea (2:1)
- Cluster bean + pigeonpea (2:1)
- Cluster bean + castor (2:1)
- Sunflower + pigeonpea (2:1)

Second fortnight of July:

- Sunflower, pigeonpea, horsegram, setaria
- Castor, pearl millet (ergot resistant)
- Intercropping of Sunflower + pigeonpea (2:1)

First fortnight of August:

- Sunflower, pigeonpea, castor, horsegram
- Sunflower + pigeonpea (2:1)

Second fortnight of August:

- Sunflower, pigeonpea, castor
- Sunflower + pigeonpea (2:1)

First fortnight of September:

- Sorghum for fodder

Second fortnight of September:

- *Rabi sorghum*, safflower, sunflower

First fortnight of October:

- *Rabi sorghum*, safflower, chickpea, sunflower

Second fortnight of October:

- Chickpea, sunflower, *rabi sorghum*

First fortnight of November:

- Chickpea, sunflower

Akola, Buldana

Regular monsoon

- The regular monsoon starts by 24th meteorological week. For regular monsoon the following recommendations stand.

Light soils (20 to 30-35 cm depth)

- Graded bunding of lands
- Growing of strips of erosion resistant crops (Greengram-Kopergaon/blackgram-T-9) in the upper half of the plot and sorghum (CSH-9) in the lower half of the plot.

Medium deep soils (35-40 cm to 75 cm depth)

- Cotton (AKH 84635) with greengram (Kopergaon) as an intercrop in 1:1 row ratio.
- Sorghum (CSH-9) with intercrop of greengram/ blackgram in 1:1 row ratio.
- Groundnut intercropped with sunflower in the row ratio of 6:2 (groundnut: JL-24, Sunflower-morden)

Deep soils (75 cm depth)

- Cotton – inter specific cultivation of hirsutum cotton (AKA-7) and AKH 4.
- Hybrid cotton AKH 4
- Sorghum CSH-9/ CSH-5 intercropped with pigeonpea (C-11) in 6:2 row ratio

Delayed onset of monsoon by 15 days

If the rains start by end of June, the sowing may start in the first week of July. The following changes should be made in the cropping plans.

- Area under cotton be reduced and replaced by sorghum.
- Sowing of sorghum should be completed before 10th July. Sorghum CSH-1 variety is sown instead of CSH-5/CSH-9.
- Area under greengram/ blackgram should be replaced by early pigeonpea varieties such as ICPL 8863 or ICPL 87119
- Area under groundnut be reduced and replaced by sunflower (EC 68414)

Regular monsoon followed by long gaps:

- Wherever possible, life-saving irrigation be given.
- Cotton can sustain some stress, but sorghum, groundnut and chickpea are not able to sustain such

stress. Therefore, use of some conditioner such as spray of urea, not exceeding 2% concentration, may be useful.

- If there is a total failure of crop, sowing of photo-insensitive crops such as *pearlmillet* (BJ-104) or sunflower (EC-68414) may be attempted.
- In deep soils, the land may be tilled properly. In case, *Kharif* crop fails, follow *rabi* crop with safflower (N.7), pigeonpea (C.11) in September.

Extended monsoon

- Advantage of this situation is exploited for double cropping with safflower and chickpea. Safflower (No.7) may be sown after sorghum till 15th October. Beyond 15th October chickpea may be sown

Jalgaon

Regular Monsoon

The regular monsoon starts by 24th meteorological week. For regular monsoon the following recommendations stand.

Light soils (depth 20 to 30-35 cm)

- Graded bunding of lands
- Growing of strips of erosion resistant crops (Greengram Kopergaon/blackgram T-9) in the upper half of the plot and sorghum (CSH-9) in the lower half of the plot.

Medium deep soils (35-40 cm to 75 cm depth)

- Cotton AKH 84635 with greengram (Kopergaon) as an intercrop in 1:1 row ratio.
- Sorghum CSH-9 with intercrop of greengram/blackgram in 1:1 row ratio.
- Groundnut intercropped with sunflower in the row ratio of 6:2 (Groundnut: JL-24, Sunflower-morden)

Deep soils (75cm depth)

- Alternate crops like hirsutum cotton, Sorghum CSH-9/ CSH-5 intercropped with Pigeonpea C-11 in 6:2 row ratio

Delayed onset of monsoon by 15 days

If the rains start by end of June, the sowing may start in the first week of July. The following changes should be made in the cropping plans.

- Area under cotton be reduced and replaced by sorghum.
- Sowing of sorghum should be completed before 10th July. Sorghum CSH-1 variety is sown instead of CSH-5/CSH-9.
- Area under greengram/blackgram should be replaced by early pigeonpea varieties such as ICPL 8863 or ICPL 87119
- Area under groundnut be reduced and replaced by sunflower (EC 68414)

Regular monsoon followed by long gaps

- Wherever possible, life-saving irrigation be given.
- Cotton can sustain some stress, but sorghum, groundnut, gram are not able to sustain such stress. Therefore, use of some conditioner such as spray of urea, not exceeding to 2 per cent concentration, may be useful.

- If there is a total failure of crop, sowing of photo-insensitive crops such as bajra (BJ-104) or sunflower (EC-68414) may be attempted.
- In deep soils, the land may be tilled properly, in case; *kharif* crop fails, to follow *rabi* crop safflower (N.7), pigeonpea (C.11) in September.

Extended monsoon

- Advantage of this situation is exploited for double cropping with safflower and chickpea. Safflower (No.7) may be sown after sorghum till 15th October. Beyond 15th October gram may be sown.

District	Region
Amaravati Nagpur Wardha Yavatmal	Medium runoff and High yield gap

Agro-ecological setting

Amaravati

- **Climate:** Hot moist semi arid
- **Physiography:** Eastern Maharashtra Plateau
- **Soils:** Medium and deep clayey black soils and shallow loamy to clayey black soils (Vertic Inceptisols– 85%; Vertisols – 15%)
- **Annual rainfall:** 976 mm
- **Potential evapotranspiration:** 1770 mm
- **Moisture availability period:** 120 – 150 days

Nagpur

- **Climate:** Hot dry sub humid
- **Physiography:** Eastern Maharashtra Plateau
- **Soils:** Shallow and medium loamy to clayey black soils, deep clayey black soils (Vertic Inceptisols – 100%) Vertisols - 60%, Inceptisols - 20%, Entisols - 20%)
- **Annual rainfall:** 1242 mm
- **Potential evapotranspiration:** 2050 mm
- **Moisture availability period:** 150 – 180 days

Wardha

- **Climate:** Hot dry sub humid
- **Physiography:** Eastern Maharashtra Plateau
- **Soils:** Shallow and medium loamy to clayey black soils, deep clayey black soils (Vertic Inceptisols -100%)
- **Annual rainfall:** 1144 mm
- **Potential evapotranspiration:** 1788 mm
- **Moisture availability period:** 150 – 180 days

Yavatmal

- **Climate:** Hot moist semi arid
- **Physiography:** Eastern Maharashtra Plateau
- **Soils:** Medium and deep clayey black soils, shallow loamy to clayey black soils (Vertic Inceptisols– 100%)
- **Annual rainfall:** 1133 mm
- **Potential evapotranspiration:** 1775 mm
- **Moisture availability period:** 120 – 150 days

Soil and water conservation

Amaravati

- Compartment bunding
- Ridges and furrows
- Graded bunds on clayey soil to drain off excess water
- *In-situ* conservation measures like tillage, mulching, conservation furrows, ridging
- Contour farming

Nagpur, Wardha and Yavatmal

- On sloppy land contour cultivation along vegetative hedge of vetiver or *Leucaena* at 0.5 m vertical interval.
- Broad bed furrows
- Compartment bunding
- Sowing across the slope
- Contour farming (cultivation and sowing along contour)

Crop management

Amaravati, Nagpur, Wardha, Yavatmal

- **Varieties:** LRA 5166, NHH-44, Ankur-651, LRA 5166, PKV Rajat, Anjali, H 4 AKH 4, AKA 5
- **Seed rate:** Varieties: 10 kg/ha; Hybrids: 3.5 kg/ha
- **Date of sowing:** 25th June to 8th July
- **Planting pattern:** Varieties- 60 x 30 cm; Hybrids: 90 x 60 cm
- **Nutrient management:**
 - 60 kg P₂O₅ + 50 kg K₂O + 10-15 t FYM/ ha.
 - 60-90 kg N/ha – in three splits (1/2 at sowing + 1/4 at squaring + 1/4 at flowering)
 - K – 1/2 to 1/3 of the dose of N.
 - Entire P and K at sowing
 - *Leucaena* loppings @ 4.5 t/ ha + 60 kg N+ 30 kg P₂O₅ / ha
- **Pest management:**
 - Summer ploughing
 - Avoid delayed sowings
 - Use of certified seeds

- Seed treatment with Captan or Thiram @ 2-3 g/kg seed
- Destruction of weeds
- Intercropping with blackgram, soybean, groundnut, setaria, maize, cowpea at two rows for every ten rows of cotton
- Trap cropping with Okra (1:10), castor, marigold
- Use of egg parasitoids *Trichogramma* sp. @ 1.5 lakh/ha
- Spray H-NPV @ 250 LE/ha
- Use of Neem oil 5%
- Spray of Quinolphos @2 l/ha or Chloripyriphos @ 2 l/ha
- Angular leaf spot / arm: Delint the seed with sulphuric acid; spray Agrimycin-10 or Pausamycin @ 75 g/ha+ copper oxychloride @ 1.87 kg/ha
- Weeding at 30 days after semi and of 60 days after sowing

Some other important practices

- Sowing in first fortnight of June
- Seed treatment with *Azospirillum* or *Azotobactor*
- Sowing: 25 June to 8 July
- 2 to 3 foliar sprays of 1-2% urea or Diammonium phosphate (DAP) at flowering and 15-20 days later.
- Cowpea grown as live mulch
- Two sprays of ploughfix (29 pm) at start flowering and at 50% flowering

Suitable cropping systems

Amaravati, Nagpur, Wardha, Yavatmal

- Cotton + sorghum (two year rotation)
- Cotton + pigeonpea (12:2)
- Cotton + soybean
- Cotton + groundnut
- Cotton + greengram (1:1)
- Cotton + blackgram

Farm implements/tools

Amaravati, Nagpur, Wardha, Yavatmal

- Manually operated fertilizer drill: Simple two row tool for top dressing (hand metered)
- Bullock drawn serrated blade for interculture: Two rows, improved blades for intercultivation.
- A four row seed cum fertilizer drill for multipurpose tool carrier (NIKARJ)
- Israeli model of tractor drawn seed drill (PDKV, Akola)

Alternate farming systems

Amaravati, Nagpur, Wardha, Yavatmal

- Fodder/ green biomass: *Leucaena leucocephala*, *Albizia lebbeck*, *Dalbergia sissoo*, *Acacia indica*, *Acacia procera*, *Glyricidia*
- Fruit: Pomegranate, ber, mango, sapota, guava, tamarind

- Medicinal and aromatic plants: *Solanum viarum*, *Catharanthus roseus*, *Palma rosa*, *Vetiveria zizanoides*, *Ocimum viride*, *Saphed Mush*.
- Vegetables: Onion, chilli, brinjal, okra, amaranths, bottlegourd, garlic.
- Animal Component: Male/ female cattle, female buffaloes, sheep, goat, poultry

Contingent planning

Amaravati

Regular Monsoon

The regular monsoon starts by 24th meteorological week. For regular monsoon, the following recommendations stand.

Light soils (depth 20 to 30-35 cm)

- Graded bunding of lands
- Growing of strips of erosion resistant crops (Greengram Kopergaon/blackgram T-9) in the upper half of the plot and sorghum (CSH-9) in the lower half of the plot.

Medium deep soils (35-40 cm to 75 cm depth)

- Cotton (AKH 84635) with greengram (Kopergaon) as an intercrop in 1:1 row ratio.
- Sorghum CSH-9 with intercrop of greengram/blackgram in 1:1 row ratio.
- Groundnut intercropped with sunflower in the row ratio of 6:2 (Groundnut JL-24, Sunflower Morden)

Deep soils (75cm depth)

- Alternate crops like hirsutum cotton, sorghum (CSH-9/ CSH-5) intercropped with pigeonpea (C-11) in 6: 2

Delayed onset of monsoon by 15 days

- If the rains start by end of June, the sowing may start in the first week of July. The following changes should be made in the cropping plans.
- Area under cotton be reduced and replaced by sorghum.
- Sowing of sorghum should be completed before 10th July. Sorghum CSH-1 variety is sown instead of CSH-5/CSH-9.
- Area under greengram/blackgram should be replaced by early pigeonpea varieties such as ICPL 8863 or ICPL 87119
- Area under groundnut be reduced and replaced by sunflower

Regular monsoon followed by long gaps

- Wherever possible, life-saving irrigation be given.
- Cotton can sustain some stress, but sorghum, groundnut, gram are not able to sustain such stress. Therefore, use of some conditioner such as spray of urea, not exceeding to 2 per cent concentration, may be useful.
- If there is a total failure of crop, sowing of photo-insensitive crops such as bajra (BJ-104) or sunflower (EC-68414) may be attempted.
- In deep soils, the land may be tilled properly, in case; *kharif* crop fails, to follow *rabi* crop safflower (N.7), pigeonpea (C.11) in September.

Extended monsoon

- Advantage of this situation is exploited for double cropping with safflower and chickpea. Safflower (No.7) may be sown after sorghum till 15th October. Beyond 15th October chickpea may be sown.

Nagpur, Wardha, Yavatmal

Regular monsoon

- The regular monsoon starts by 24th meteorological week. For regular monsoon the following recommendations stand.
- **Light soils (20 to 30-35 cm depth)**
 - Graded bunding of lands
 - Growing of strips of erosion resistant crops (Greengram Kopergaon/blackgram T-9) in the upper half of the plot and sorghum (CSH-9) in the lower half of the plot.
- **Medium deep soils (35-40 cm to 75 cm depth)**
 - Cotton (AKH 84635) with greengram (Kopergaon) as an intercrop in 1:1 row ratio.
 - Sorghum (CSH-9) with intercrop of greengram/ blackgram in 1:1 row ratio.
 - Groundnut intercropped with sunflower in the row ratio of 6:2 (groundnut: JL-24, Sunflower-morden)
- **Deep soils (75 cm depth)**
 - Cotton – inter specific cultivation of hirsutum cotton (AKA-7) and AKH 4.
 - Hybrid cotton AKH 4
 - Sorghum CSH-9/ CSH-5 intercropped with pigeonpea (C-11) in 6:2 row ratio

Delayed onset of monsoon by 15 days

If the rains start by end of June, the sowing may start in the first week of July. The following changes should be made in the cropping plans.

- Area under cotton be reduced and replaced by sorghum.
- Sowing of sorghum should be completed before 10th July. Sorghum CSH-1 variety be sown instead of CSH-5/CSH-9.
- Area under greengram/ blackgram should be replaced by early pigeonpea varieties such as ICPL 8863 or ICPL 87119
- Area under groundnut be reduced and replaced by sunflower

Regular monsoon followed by long gaps:

- Wherever possible, life-saving irrigation be given.
- Cotton can sustain some stress, but sorghum, groundnut and chickpea are not able to sustain such stress. Therefore, use of some conditioner such as spray of urea, not exceeding 2% concentration, may be useful.
- If there is a total failure of crop, sowing of photo-insensitive crops such as *pearlmillet* (BJ-104) or sunflower (EC-68414) may be attempted.
- In deep soils, the land may be tilled properly. In case, *Kharif* crop fails, follow *rabi* crop with safflower (N.7), pigeonpea (C.11) in September.

Extended monsoon

- Advantage of this situation is exploited for double cropping with safflower and chickpea. Safflower (No.7) may be sown after sorghum till 15th October. Beyond 15th October chickpea may be sown

District	Region
Chandrapur Jalna	High runoff and High yield gap

Agro-ecological setting

Chandrapur

- **Climate:** Hot dry / moist sub humid
- **Physiography:** Eastern Maharashtra Plateau
- **Soils:** Shallow and medium loamy to clayey black soils and deep clayey black soils, deep loamy red and lateritic soils (Vertic Inceptisols– 100%)
- **Annual rainfall:** 1474 mm
- **Potential evapotranspiration:** 1579 mm
- **Moisture availability period:** 150 – 210 days

Jalna

- **Climate:** Hot semi arid
- **Physiography:** Central Maharashtra Plateau
- **Soils:** Shallow and Medium loamy and medium and deep clayey black soils (Vertic Inceptisols 75%; Vertisols – 25%)
- **Annual rainfall:** 1472 mm
- **Potential evapotranspiration:** 1559 mm
- **Moisture availability period:** 120 – 150 days

Soil and water conservation

Chandrapur

- On sloppy land contour cultivation along vegetative hedge of Vetiver or *Leucaena* at 0.5 m vertical interval.
- Broad bed furrows
- Compartment bunding
- Sowing across the slope
- Contour farming (cultivation and sowing along contour)

Jalna

- Compartment bunding
- Ridges and furrows prior to sowing
- Marvel –8 grass on bunds for protection of bunds
- Contour live bunds of Marvel-8 or *Leucaena*
- *Leucaena* loppings mulch at 3.5 t/ha

Crop management

Chandrapur

- **Varieties:** LRA 5166, NHH-44, Ankur-651, LRA 5166, PKV Rajat, Anjali, H 4, AKH 4, AKA 5

- **Seed rate:** Varieties: 10 kg/ha; Hybrids: 3.5 kg/ha
- **Date of sowing:** 25th June to 8th July
- **Planting pattern:** Varieties- 60 x 30 cm; Hybrids: 90 x 60 cm
- **Nutrient management:**
 - 60 kg P₂O₅ + 5 0kg K₂O + 10-15 t FYM/ ha.
 - 60-90 kg N/ha – in three splits (1/2 at sowing + 1/4 at squaring + 1/4 at flowering)
 - K – 1/2 to 1/3 of the dose of N.
 - Entire P and K at sowing
 - *Leucaena* loppings @ 4.5 t/ ha + 60 kg N+ 30 kg P₂O₅ / ha
- **Pest management:**
 - Summer ploughing
 - Avoid delayed sowings
 - Use of certified seeds
 - Seed treatment with Captan or Thiram @ 2-3 g/kg seed
 - Destruction of weeds
 - Intercropping with blackgram, soybean, groundnut, setaria, maize, cowpea at two rows for every ten rows of cotton
 - Trap cropping with Okra (1:10), castor, marigold
 - Use of egg parasitoids *Trichogramma* sp.@ 1.5 lakh/ha
 - Spray H-NPV @ 250 LE/ha
 - Use of Neem oil 5%
 - Spray of Quinolphos @2 l/ha or Chloripyrifhos @ 2 l/ha
 - Angular leaf spot / arm: Delint the seed with sulphuric acid; spray Agrimycin-10 or Pausamycin @ 75 g/ha+ copper oxychloride @ 1.87 kg/ha
 - Weeding at 30 days after semi and of 60 days after sowing
- **Some other important practices**
 - Sowing in first fortnight of June
 - Seed treatment with *Azospirillum* or Azotobactor
 - Sowing: 25 June to 8 July
 - 2 to 3 foliar sprays of 1-2% urea or Diammonium phosphate (DAP) at flowering and 15-20 days later
 - Cowpea grown as live mulch
 - Two sprays of ploufix (29 pm) at start flowering and at 50% flowering

Jalna

- **Varieties:** LRA 5166, NHH-44, Ankur-651
- **Seed rate:** Varieties: 10 kg/ha; Hybrids: 3.5 kg/ha
- **Date of Sowing:** 25th June to 8th July
- **Planting pattern:** Varieties- 60 x 30 cm; Hybrids: 90 x 60 cm
- **Nutrient management:** 100 kg N (in two splits i.e., half at first square formation and half at peak flowering) + 50 kg P₂O₅ + 5 0kg K₂O + 10-15 t FYM/ ha. Entire P and K at sowing
- **Pest management:**
 - Summer ploughing
 - Avoid delayed sowings
 - Use of certified seeds

- Seed treatment with Captan or Thiram @ 2-3 g/kg seed
- Destruction of weeds
- Intercropping with blackgram, soybean, groundnut, setaria, maize, cowpea at two rows for every ten rows of cotton
- Trap cropping with Okra (1:10), castor, marigold
- Use of egg parasitoids *Trichogramma* sp. @ 1.5 lakh/ha
- Spray H-NPV @ 250 LE/ha
- Use of Neem oil 5%
- Spray of Quinalphos @2 l/ha or Chloripyriphos @ 2 l/ha
- Angular leaf spot/arm: Delint the seed with sulphuric acid; spray Agrimycin-10 or Pausamycin @ 75 g/ha+ copper oxychloride @ 2.0 kg/ha
- Weeding at 30 days after semi and of 60 days after sowing
- **Some other important practices**
 - Sowing in first fortnight of June
 - Seed treatment of with *Azospirillum* or *Azotobacter*

Suitable cropping systems

Chandrapur

- Cotton + sorghum (two year rotation)
- Cotton + pigeonpea (12:2)
- Cotton + soybean
- Cotton + groundnut
- Cotton + greengram (1:1)
- Cotton + blackgram

Jalna

- Cotton + pigeonpea
- Cotton + sorghum

Farm implements/ tools

Chandrapur

- Manually operated fertilizer drill: Simple two row tool for top dressing (hand metered)
- Bullock drawn serrated blade for interculture: Two rows, improved blades for intercultivation.
- A four row seed cum fertilizer drill for multipurpose tool carrier (NIKART)
- Israeli model of tractor drawn seed drill (PDKV, Akola)

Jalna

- Tractor multicrop planter. Sowing of *rabi* sorghum was done on farmer's field. Minor modifications made in the original design for adoption of the machine in dryland region. Awareness was created amongst the farmers by conducting demonstrations on farmer's field. The farmers were satisfied with operation of this machine. Rs.22800/-
- Bullock drawn Jyoti Planter. The field trials were conducted and the machine is recommended for sowing the crops of dryland region. Rs.7500/-

- Weeders developed by Maharashtra Agro Industries Development Corporation Ltd. (MAIDC). These weeders were tested on farmer's field and identified for weeding and interculturing in row crops. Rs.410/-
- Tractor drawn single bottom reversible plough. Tested on farmers' field for ploughing and identified for ploughing operations in dryland region as the field operation was effective and economical. Rs 18500/-
- Tractor drawn double bottom reversible plough. Tested on farmers' field for ploughing and identified for ploughing operations in dryland region as the field operation was effective and economical. Rs. 23600/-
- Bund formers were tested and found suitable for Compartment bunding. Rs.1050/-
- Baliram plough. Identified for moisture conservation practices like ridges and furrows and compartment bunding. Rs.2500/-
- Israeli model of tractor drawn seed drill (PDKV, Akola)
- Kopergaon bullock drawn two bowl seed drill. The local made seed drill named "Kopergaon seed drill" is operated on the field for sowing crops like sorghum, pearl millet, pigeonpea etc. and identified for sowing of the crops of dryland region. Rs.9000/-
- A four row seed cum fertilizer drill for multipurpose tool carrier (NIKART)

Alternate farming systems

Chandrapur

- Fodder/green biomass: Stylosanthes sole and stylosanthes-marvel pastural system recorded higher green fodder yield than sole or combination of grasses, *Leucaena leucocephala*, *Albizia lebbeck*, *Delbergia sissoo*, *Acaica indica*, *Acacia procera*, *Gliricidia*
- Fruit: Ber agro-horticulture system (Ber+ short duration Legume crop) was found more remunerative than amla and custard apple horticulture system. Pomegranate, ber, mango, sapota, guava, tamarind
- Medicinal and aromatic plants: *Solanum viarum*, *Catharanthus roseus*, *Palmrosa*, *Vetiveria zizanioides*, *Ocimum viride*
- Vegetables: Onion, chilli, brinjal, okra, amaranthus, bottlegourd
- Animal component: Female Cattle, Male Cattle, Female Buffaloes, Goat, Poultry

Jalna

- Agri-horticultural system - Ber (5x5 m) + mothbean (8 lines) (30x10 cm)
- Silviculture: *Leucaena* + *Marvel* –8
- Alley cropping: Ber (20 m alleys) + pearl millet + pigeonpea for shallow soils
- Fodder: Maize (African Tall), Oats (Kent), *Stylosanthes hamata*
- Fodder/ green biomass: *Alianthus excelsa*; *Albizia lebbeck*, *Dalbergia sissoo*, *Azadirachta indica*, *Prosopis cineraria*
- Fruit: Ber, Date palm, jamun, fig, phalsa, karonola
- Medicinal / aromatic plants: *Plantago ovata*, *Cassia angustifolia*, *Safed musli*, *Papaver somniferum*
- Vegetables: Clusterbean, cowpea, amaranthus, round melon, Long melon
- Animal component: Female buffalo/ sheep, goat

Alternate land use system

Jalna

- Lands < 22.5 cm depth of soil should be cultivated with agroforestry and dryland horticulture including ber, custard apple, amla, wood apple, jambhul.
- On light soils Ber cultivation at 20x5 m spatial arrangement associated with pearl millet + pigeonpea (2:1) intercropping within two rows of Ber plantation was recommended.
- Silvopastoral system of Subabul + Marvel-8 with cutting of the alternate trees at 7th year onwards for fuel is also recommended.
- For productivity increment in scarcity area pearl millet + pigeonpea (2:1) intercropping or Ber (5x5 m) + mothbean (8 lines) is advocated.

Contingent crop planning

Chandrapur

Regular monsoon

The regular monsoon starts by 24th meteorological week. For regular monsoon the following recommendations stand.

- **Light soils (20 to 30-35 cm depth)**
 - Graded bunding of lands
 - Growing of strips of erosion resistant crops (Greengram Kopergaon/blackgram T-9) in the upper half of the plot and sorghum (CSH-9) in the lower half of the plot.
- **Medium deep soils (35-40 cm to 75 cm depth)**
 - Cotton (AKH 84635) with greengram (Kopergaon) as an intercrop in 1:1 row ratio.
 - Sorghum (CSH-9) with intercrop of greengram/ blackgram in 1:1 row ratio.
 - Groundnut intercropped with sunflower in the row ratio of 6:2 (groundnut JL-24, Sunflower Morden)
- **Deep soils (75 cm depth)**
 - Cotton – inter specific cultivation of hirsutum cotton (AKA-7) and AKH 4
 - Hybrid cotton AKH 4
 - Sorghum CSH-9/ CSH-5 intercropped with pigeonpea (C-11) in 6:2 row ratio

Delayed onset of monsoon by 15 days

If the rains start by end of June, the sowing may start in the first week of July. The following changes should be made in the cropping plans.

- Area under cotton be reduced and replaced by sorghum.
- Sowing of sorghum should be completed before 10th July. Sorghum CSH-1 variety is sown instead of CSH-5/ CSH-9.
- Area under greengram/ blackgram should be replaced by early pigeonpea varieties such as ICPL 8863 or ICPL 87119
- Area under groundnut be reduced and replaced by sunflower

Regular monsoon followed by long gaps:

- Wherever possible, life-saving irrigation be given.
- Cotton can sustain some stress, but sorghum, groundnut and chickpea are not able to sustain such stress. Therefore, use of some conditioner such as spray of urea, not exceeding 2% concentration, may be useful.

- If there is a total failure of crop, sowing of photo-insensitive crops such as pearl millet (BJ-104) or sunflower (EC-68414) may be attempted.
- In deep soils, the land may be tilled properly. In case, *Kharif* crop fails, follow *rabi* crop with safflower (N.7), pigeonpea (C.11) in September.

Extended monsoon

- Advantage of this situation is exploited for double cropping with safflower and chickpea. Safflower (No.7) may be sown after sorghum till 15th October. Beyond 15th October chickpea may be sown

Jalna

Mid season corrections during *Kharif* with soil having depth upto 45 cm for the scarcity zone.

Second fortnight of June:

- All *Kharif* crops

First fortnight of July:

- Pearl millet, setaria, groundnut, castor, pigeonpea, horsegram
- Intercropping of pearl millet + pigeonpea (2:1)
- Cluster bean + pigeonpea (2:1)
- Cluster bean + castor (2:1)
- Sunflower + pigeonpea (2:1)

Second fortnight of July:

- Sunflower, pigeonpea, horsegram, setaria
- Castor, pearl millet (ergot resistant)
- Intercropping of Sunflower + pigeonpea (2:1)

First fortnight of August:

- Sunflower, pigeonpea, castor, horsegram
- Sunflower + pigeonpea (2:1)

Second fortnight of August:

- Sunflower, pigeonpea, castor
- Sunflower + pigeonpea (2:1)

First fortnight of September:

- Sorghum for fodder

Second fortnight of September:

- *Rabi* Sorghum, Safflower, Sunflower

First fortnight of October:

- *Rabi* Sorghum, Safflower, Chickpea, Sunflower

Second fortnight of October:

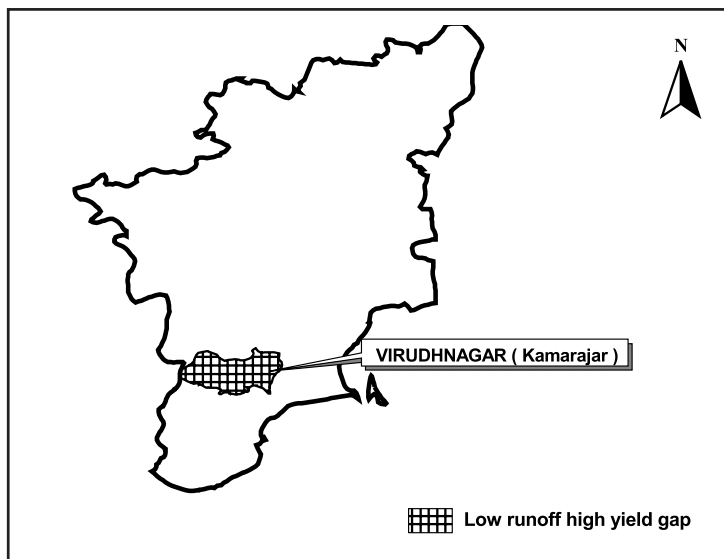
- Chickpea, Sunflower, *Rabi* Sorghum

First fortnight of November:

- Chickpea, Sunflower

TAMIL NADU

There is one district viz., Virudhnagar, under low run off and high yield gap region.



District	Region
Virudhnagar (Kamarajar)	Low runoff and High yield gap

Agro-ecological setting

- **Climate:** Hot dry semi arid
- **Physiography:** Tamil Nadu Uplands
- **Soils:** Moderately deep to deep, loamy to clayey mixed red and black soils (Alfisols – 100%)
- **Annual rainfall:** 1158 mm
- **Potential evapotranspiration:** 1752 mm
- **Moisture availability period:** 90–120 days

Soil and water conservation

- Soil water balance studies
- Runoff-erosion measurements
- More emphasis on *insitu* water conservation
- Increasing soil infiltration capacity and reducing soil crusting problem
- Inter-plot water harvesting of 1:1 cropped to uncropped land
- Dead furrows at 3.6 m interval
- Absorption/ drainage type terraces

Crop management

- **Varieties:** Anjali, MCU-5, KC-2
- **Seed rate:** 20 kg/ha
- **Planting pattern:** 45 x 30 cm
- **Nutrient management:** 40 kg N + 20 kg P₂O₅/ha
- **Pest management:**
 - Weed management (mechanical)
 - One hand weeding using hand hoe and keep fields weedfree for the first 35 days after sowing.
 - Weed Management (chemical)

Crop	Herbicide	Dose (kg a.i./ha)	Methods of application
Cotton + Blackgram	Pendimethalin 3.3l/ha	3.31/ha	Broadcast after mixing
Cotton	Butachlor 3.3l/ha	3.31/ha	with sand

- Spraying of Methyldemeton @ 0.025% thrice from 15 days after sowing at 15 days interval for Jassids, aphids and thrips
- Spraying of Phosalone (2 l/ha) or Monocrotophos (1.25 l/ha) or Endosulfan (2 l/ha) from 55, 65, 75, 85, 95, 105, 115 and 125 days after sowing or Dusting six times with Endosulfan 4% or Carbaryl 5 % dust @ 25 kg/ha on 21st, 45th, 60th, 75th and 105th days after sowing for Boll worms

Suitable cropping system

Intercropping

- Sorghum (K8) + cowpea (C.152) or pigeonpea in inter-spaces
- Cotton (KC.2) 50 + blackgram (K1) or greengram (CO 5) in paired row system (2:1)
- Cotton + blackgram
- Cotton + thenai/ carriander
- Cotton + clusterbean (2:1)
- Sorghum + cowpea
- Sorghum + black gram
- Sorghum + greengram
- Sorghum + siratro (fodder) (1:1)
- Maize + greengram
- Pearl millet + clusterbeans

Farm implements/ tools

- Tractor drawn seed drill
- Bullock drawn seed drill
- Multipurpose implement

TNAU, Coimbatore has developed number of sowing devices with cup feed mechanism for sowing different type of seeds. They are suitable for sowing cotton also.

- Bullock drawn 3 tyned seed planter. It has shoe type furrow opener.
- Cultivation mounted tractor drawn seed planter.
- Improved broad bed farmer cum seeder suitable for farming and sowing simultaneously in raised beds.
- Basin lister attached cultivation mounted seed planter suitable for farming basins in between rows while sowing itself for conserving moisture in dryland cultivation.
- The above unit modified to form broad beds while sowing by removing the basin lister attachment and fixing the broad bed attachment.
- A trencher drawn irrigation channel former, which is useful for forming irrigation channels in irrigated cultivation.
- A tractor drawn trencher suitable for drainage purpose where there is water logging during rainy season.
- Single row spindle type cotton picker.
- These machines, though profitable, are meant for bigger farms. Small and cheaper machines suitable to Indian conditions are needed because of small size of holdings. TNAU is currently engaged in development of small and

Alternate farming systems

- **Alley cropping:** Subabul (6 m width) + sorghum/ pearl millet/ pigeonpea
- Subabul (6 m width) + mulching with Subabul leaves in alleys + cotton/ blackgram/ sunflower
- **Agroforestry:** Tamarind/ neem + sorghum (K-8), tamarind/ neem + blackgram (C0-5)
- **Agro-horti system:** Tamarind (PKM-1) + blackgram (K-1)
- **Silvipasture:** *Alianthus excelsa* + Blackgram, *Alianthus excelsa* + Dinanath grass
- **Fodder/ green biomass:** *Alianthus excelsa*, *Albizia lebbeck*, *Leucaena leucocephala*, *Hardwickia binata*, *Azadirachta indica*
- **Fruit:** Mango, Sapota, Fig, Jamun, Pomegranate
- **Medicinal/ Aromatic Plants:** *Cassia aungstifolia*, *Palma rosa*, *Vetiveria zizanooides*, *Jasmine*, *Rose*, *geranium*
- **Vegetables:** Okra, Bittergourd, Ridge gourd, Chillies, Brinjal, Amaranthus
- **Animal Component:** Sheep, Goat

Integrated farming System

In drylands, maintenance of two milch cows along with agricultural component indicated that percentage contribution of agricultural component to the total gross and net income of Integrated Farming system was 10 and 6.7% as compared to the percentage contribution of dairy component with 90 and 93.3%.

Contingent planning

- Normal monsoon conditions: With the onset of north-east monsoon in September – October, crops like sorghum, cotton, pearl millet, pulses and oilseeds can be sown. Sorghum (K.Tall or K.8) may be sown during September
- Delayed onset of monsoon: If the rains are received late in October, pearl millet (WCC75) can be sown. Pulses like blackgram, greengram and oilseeds like sunflower (K1) can be grown if the rains are received later.
- Very delayed monsoon: Sunflower (K1), Sesame (TMV 3), senna and coriander can be sown upto the first week of November under very delayed monsoon conditions.
- Early withdrawal of monsoon: Short duration crops like pearl millet (Co.6 and X 4) with 75 days duration and sunflower (K1) with 65 days duration are grown.
- Cultural practices like shallow intercultural to eradicate weeds, maintain soil mulch to conserve soil moisture, application of surface mulch, thinning of crops by removing alternate rows as in pearl millet and recycling of stored runoff water are generally resorted to.

Summary

Soils are graded from most suitable to unsuitable to cotton growing according to the soil-site characteristics.

Climatic and soil-site suitability characteristics for cotton at different degrees of limitations

Soil Site characteristics	Degrees of limitation				
	0 S1 (Most suitable)	1 S2 (Critical)	2 S3 (Less suitable)	3	4 N1 (Not suitable)
Climatic Characteristics					
Annual rainfall (mm)	1200-1000	1000-850	850-700	700-550	550
Rainfall during growing season (mm)	1000-850	850-750	850-700	700-550	550
Length of growing season (days)	28-26	26-24	24-22	22-20	20
Mean temp during growing season (°C)	28-26	26-24	24-22	22-20	20
Mean max. temp during growing season (°C)	35-32	32-28	28-26	26-24	24
Mean R.H. in growing season	50	50-60	60-70	70-80	80
Length of dry spells (weeks)					
July (beginning) August (end)	1	1	1-2	2-3	3-4
	1	1-2	2-3	3+	4+
Site characteristics					
Slope (%)	0-1	1-3	1-3	3-5	5-8 or more
Erosion	°0	°1	°2	°2-3	°3
Drainage (internal and external)	Well	Well	Mod. well	Imperfect somewhat excess	Excess
Ground water table (m)	3	2-3	1-2	1	1
AWC (mm/m)	200	150-200	100-150	50-100	50
Stoniness % (surface)	3	3-15	15-40	40-75	75
Soil characteristics					
Texture	Clayey, sandy clay (structural)	Clay loam, silt clay loam, sandy clay (Fine silty)	Loamy, silty loam clayey sandy loam (very fine)	Sandy loam loamy sand (coarse loamy)	Sandy
Coarse fragments (Vol%):					
Within 50 cm	5	5-15	15-40	40-75	75
Below 50 cm	5	15-40	40-75	75	-
Effective depth (cm)	120	120-80	80-50	50-25	25
CaCO ₃ (%)	2	2-4	4-8	8-15	15
ESP:					
Loamy texture	10	10-15	15-25	25-40	40
Fine texture	5	5-10	10-15	15-25	25

Source: Sehgal, *et al.* 1989

Cropping systems

Popular hirsutum, varieties and hybrids for different states are given below.

Cotton growing zones, their soils and important cotton species, varieties and hybrids grown

State	G.hirsutum	G.arboreum	Hybrid
Central Zone: Soils – Black			
Madhya Pradesh	Khandwa 3, Vikram, Khandwa 2	Maljari, Jawhar Tapti	JKHy.1, 28, 29, 30
Maharashtra	PKV.081, Anjali, LRA.5166, Rajat	PA.183, AKH.4, AKH.5, AKA.8401, Rohini,	JKHy.2, PKVHy.3, NHH.44, Ankur 651 RCH.2
Gujarat	G.Cot.12, LRK.516, G.Cot	G.Cot.13, GCot.17, V.797	G.Cot Hyb.6 G.Cot Hyb.8, G.Cot.Hyb.10
South Zone: Soils – Black, Red, Laterite			
Andhra Pradesh	LRA.5166, LK.861, L.389, Kanchana	Srisailam, Mahanandi, NA.1315	JKHy.1, DCH.32, NHH.44, Savita, RCH.2, MECH
Karnataka	Sharda, JK 119, Abhadita	Raichur 51*, DB.3-12*, Jayadhar*	DCH.32, DHB.105, DHH.11, NHH.44
Tamil Nadu	MCU.5, MCU.5 VT, MCU.7 LRA.5166, Anjali (LRK.516) Surabhi, Supriya, SVPR.2	K.12	Savit, DCH.32, TCHB.213 RCH.213 DBH 105

*G.herbaceum,

(Mannikar and Venugoplan, 1999)

The information on varieties/ hybrids releases during 1996-2002 from the Annual Report(s), Department of Agricultural Research and Education, Ministry of Agriculture, Government of India, and Indian Council of Agriculture Research, New Delhi are summarized below. Apart from the rainfed region information is also included on dry irrigated regions. This information may be read in conjunction with the recommendation of the centers for cotton. The details follow.

Varieties released during 1996-2002

Cultivar	Recommended region	Salient features (Year of release)
AAH 1	Rajasthan	<i>Intra-arboreum</i> hybrid. First genetic male sterility based desi hybrid (1998-99)
AKA 7	Vidarbha region of Maharashtra	<i>Arboreum</i> . Medium staple (1998-99)
G.Cot 19	Mathio cotton area of Gujarat	<i>Arboreum</i> . Medium staple variety with resistance to bacterial blight, grey mildew and Alternaria leaf spot (1998-99)
G.Cot.18	Saurashtra region of Gujarat	Long staple, 2.5-3t/ha, maturity 160 days (1999 – 2000)
Jawahar Tapti	Madhya Pradesh, Chattisgarh	(1997-98)
JKHY 2	Madhya Pradesh, Chattisgarh	<i>Intra hirsutum</i> hybrid (1997-98)
WHH 09	Madhya Pradesh, Maharashtra	<i>Intra hirsutum</i> hybrid (1997-98)
KC 2	Southern districts of Tami Nadu	<i>Gossypium hirsutum</i> (1997-98)

Cultivar	Recommended region	Salient features (Year of release)
Sruthi	Coastal rice fallows tracts of South Zone	Interspecific hybrids (<i>G. hirsutum</i> x <i>G. Arboreum</i>) (1997-98)
K11	Southern Tamil Nadu	<i>Gossypium arboreum</i> (1997-98)
L 603	Andhra Pradesh	<i>Gossypium hirsutum</i> . Medium staple with resistance to <i>jassids</i> (1998-99)
L 604	Andhra Pradesh	<i>Gossypium hirsutum</i> . Medium staple with moderate resistance to <i>jassids</i> (1998-99)
LAHH 4	Andhra Pradesh	Intra <i>hirsutum</i> hybrid. Medium-staple (1998-99)

Cotton cultivation in India especially for the rainfed areas, is always a combination of mixed cropping and intercropping, while in the high rain fall zones, cotton is grown in sequential cropping as double or triple cropping sequences and in extreme cases going in for intensive relay cropping. During initial stage growth rate of cotton is slow. Therefore it is beneficial to take short duration intercrops. Mainly short duration cereals like blackgram, greengram and soybean is suitable. Intercropping is taken as 2:1 proportion. That is two rows of cotton and one row of intercrop. The pest and disease incidence never assumes serious proportions only because of such diversified cropping systems. Monocropping is followed when the total rainfall ranges between 500 to 600 mm with soils having moisture storage capacity of 100 mm, while intercropping is possible if the total rainfall is 600 to 800 mm and moisture storage capacity is 150 mm. With rainfall above 900 mm and soil moisture storage capacity above 200 mm, sequence cropping becomes possible. It is also seen that in the mixed or intercropping, generally a pulse, oilseeds or cash crop is included for maintaining better soil productivity and fetching higher economic returns from the cropping system. Popular systems are given below.

Cotton based cropping systems in various states

State	Cropping System
Madhya Pradesh, Maharashtra and Gujarat	Cotton (monocrop), cotton-sorghum two year rotation), cotton-wheat, cotton intercropped with blackgram, greengram, soyabean, groundnut and red gram.
Tamil Nadu	Cotton (monocrop), rice-cotton, rice-rice-cotton, cotton-jowar, cotton-pulse-sorghum, cotton intercropped with onion, groundnut, blackgram.
Andhra Pradesh	Cotton (monocrop), cotton-rice (1 year), cotton-chilli or cotton-tobacco (two year rotation)
Karnataka	Cotton (monocrop), cotton-wheat, cotton intercropped with chilli, groundnut, blackgram, greengram.

(Mannikar and Venugopalan, 1999)

Cotton based intercropped area is in about 70,000 hectares in Karnataka, which is mostly under rainfed conditions (17% of rainfed cotton areas). Intercropping in cotton on large scale is restricted to Dharward, Bijapur and Belgaum districts and to lesser extent in Bellary, Raichur and Chitradurga districts. However, intercropping of cotton with vegetables like onion, chilli, clusterbean, beetroot and also with groundnut, greengram, wheat and maize was found more profitable in irrigated areas as well as assured rainfall areas of Karnataka. Intercropping of chilli and cotton is a common practice in the assured rainfall areas of Karnataka. Chilli-onion-cotton (Jayadhar) intercropping system has become an established practice under rainfed conditions in Dharward district. For the uplands of high rainfall tracts of Karnataka, intercropping of rice with cotton hybrid DCH 32, enhanced the kapas yield by 33% compared to sole crop of cotton.

The area under cotton in the Vidarbha region of Maharashtra is 1.6 m hectares out of which 97% is rainfed. Short duration crops like greengram, blackgram, pigeonpea, soybean, groundnut, etc. are preferred as intercrops in cotton in this region. Mixed cropping of cotton and red gram is very popular. Cotton-groundnut and cotton-greengram intercropping system were found to be remunerative. Of late, cotton-blackgram intercropping system has also been found profitable. In South Gujarat, hybrid cotton is intercropped with groundnut, gingelly, greengram or blackgram. In general, blackgram was found to be more profitable than greengram as an intercrop in cotton. Paired row planting of 1:1 or 2:1 was found more remunerative than normal row planting of cotton. Soyabean intercropped in cotton in 1:1 or 2:1 row ratios gave higher monetary returns over cotton alone.

Plant population and geometry

In case of dwarf, compact varieties closer spacing with higher population has given best results. In parts of Gujarat and Andhra Pradesh, wider spacings of 150 x 60 cm and 120 x 60 cm are followed for hybrid cottons like G.Cot. Hyb.6, RCH.2, Vikram and Nath hybrids. However, in many regions, 90 x 60 cm is followed for hybrids and high yielding varieties under high yielding situations. Increase in yield owing of closer spacing and higher population has been reported. Recommended seed rate, spacing and population are given below.

Seeding of various cotton species

Species	Zone	Seed (kg/ha)	Spacing (cm)	Plants/ ha
<i>G.arboreum</i> and <i>G. herbaceum</i>	Central	12-15	45 x 60	88,900
	Southern	12-15	60 x 30	55,600
Hybrids (Intra and Inter-specific)	Central	3.0-3.5	150 x 60	11,111
	Southern	2.5-3.0	120 x 60	13,900
<i>G. hirsutum</i>	Central	10-12	60 x 30	55,600
	southern	15-20	45 x 30	74,000

(Venugopalan et al, 1999)

In case of the ridge-sown crop hand dibbling of the seeds at the recommended spacing is commonly followed. Indigenous variety - 45x22.5 cm. American variety - 60x30 cm. Hybrid varieties - 60x60 cm; 75x75 cm; 90x90 cm. Small shallow holes should be prepared on middle of the ridge upto 2-3 inch deep and applied recommended fertilizers and 1.0-1.5 g of Thimmet and cover it with the soil. On each hill 3-4 cotton seeds should be dibble and cover completely with the soil and apply irrigation immediately. Rainfed crop is sown in June-July with the commencement of the monsoon. In South India the major portion of the rainfed crop is planted in September-October, whereas the sowing of the rainfed crops extended up to November. In Karnataka desi cotton is usually sown in August-September. If there is no germination after seven days of sowing and there is gap then fill that gap by dibbling the cotton seeds. Also during thinning fill the gap by planting the cotton plants. It is necessary to carry out thinning operation after 15-20 days of sowing keeping only two healthy plants at each hill.

Soil and water conservation

Under rainfed cotton cultivation, moisture conservation of rainwater can be achieved by following ridge and furrow method, broad bed cultivation, planting on 0.2% contours and tying the ridges in September i.e. at the cessation of monsoon. Deep ploughing, interculturing and application of organic manures can increase moisture-holding capacity of soil. Generally, deep ploughing is advocated once in 2 to 3 years to eradicate the deep-rooted weeds are sufficient for black soils. In many rainfed areas, deep tillage followed by suitable drainage practices tend to keep the rhizosphere in the best possible physical condition for plant growth. Higher Land Equivalent Ratio with higher monetary benefit was seen with cotton under Compartment bunding with 33% intercropping density. The practice of ridges and furrows planting (onion on ridges and cotton in furrows) was seen ideal for planting cotton-onion combination. In rainfed areas of central and south zone states, water harvesting through nala beds and construction of tanks in natural depressions help in storing water for use in the post-rainy season as protective irrigation. Supplemental irrigation in alternate furrows, application of water at critical stages of crop growth, use of drip and sprinkler irrigation result in saving of water and better soil water use efficiency. In tracts of heavy soils of Peninsular India, cotton crop suffers from waterlogging caused by heavy or incessant rains. Inadequate drainage results in loss of N in soil and appearance of yellowing of leaves. The provision of diversion drains helps safe disposal of water which otherwise can erode the land.

The crop is sown in medium to deep soils when at least 75 to 100 mm of rainfall is received with the onset of monsoon. Early sowing by 7-15 days in cotton is also proved to be beneficial than the normal sowing as the cotton yields are increased by 15-45% due to advance sowing. Advance sowing can be done by following crow bar method in first week of June or transplanting the raised seedlings in polythene bags

(for hybrid) after the onset of monsoon. Advance sowing favors early canopy cover and the crop often escapes damage due to insect pests as well as soil erosion.

Poor crop yields may be attributed to initially low plant population because of crust formation. Farmers generally try to break the crust by mechanical means but due to high cost involved and ineffectiveness of such operation, this method has not proved successful. Sometimes seedlings get damaged during the farm operation. Other non-mechanical methods are reducing film, alumina, CaCl_2 , compost, phosphate, cluster beans (for sowing with cottonseed) and wheat *bhusa*. The application of wheat *bhusa* @ 200 kg/ha on seed lines increased significantly the seedling emergence of crusted soils. Black polythene, wheat *bhusa*, jowar straw and other crop residue are useful mulches and found beneficial in reducing evaporation losses and increasing cotton production.

Incorporation of FYM, compost or green manures and inclusion of legumes in rotation improves the soil structure. Structural improvement property of legumes is further enhanced by phosphate application. In addition to the role of increase biological activity, phosphatic compounds cause soil aggregation and thus improve condition and productivity of soil. Combined use of organics with inorganics (integrated nutrient management) has been found to improve the soil physical properties particularly soil structure and help in maintaining the soil productivity on long term basis

Cotton is sensitive for weed growth as weeds compete for water light and nutrients. If there are no control measures of weeds upto 70 days from cotton sowing there is chances of reduction in cotton production due to unsatisfactory growth of cotton crop. Therefore it is essential to keep the field weed free upto 2 months from sowing. To control the weeds 1-2 hand weedings and 2 harrowings should be done.

Moisture depletion pattern in case of fine textured soils indicate that moisture extraction is largely restricted to the surface 60 cm. Cotton on medium textured soils develops an extensive root system which enables it to extract water from 120-150 cm depth of soil. Cotton on medium textured soils needs only one to two supplemental irrigations depending on the rainfall to produce satisfactory yields.

Soil fertility management

'Red leaf disease' appears during peak flowering or bolling stage of growth, resulting in reddening of leaves and cracking of bolls leading to lower yields. This problem is attributed to Mg deficiency, lower N content in leaf sudden fall in night temperature and lower available N status of soil. This problem can be tackled by foliar spray of 1% MgSO_4 or urea or DAP at 2% concentration. 'New Cotton Wilt', though not directly associated with soil, occurs during September/ October. Wilt affected leaves contain lower N, Mg and K than that of healthy leaves. This problem is observed when heavy rainfall occurs after prolonged drought. 'Bud and boll shedding' in cotton is a common phenomena and occur in late August or September. Lower nutrient or moisture status of soil at this stage of crop results in bud and boll shedding. Split application of fertilizers or foliar spray along with light irrigation is recommended.

In case of rainfed cotton fertilizer dose for desi variety is 50:50:25kg/ha N- P_2O_5 - K_2O . For hybrid varieties fertilizer dose is 80:40:40kg/ha N- P_2O_5 - K_2O . 1/4 nitrogen and whole phosphorus and potash is given at the time of sowing while 1/2 nitrogen is given 4 weeks after sowing and remaining 1/4 nitrogen is given through spraying. Due to cultivation of high yielding varieties or hybrids, inadequate use of organic manures and application of chemical fertilizers, the need for application of S, Zn, Fe, Mn and B is being felt. Generally there is no problem of Ca and Mg in our soils. However, Ca and Mg become important in acid soils as they are deficient in acidic conditions. This problem can be taken care of, if we apply 3-5 tonnes of lime to the soil per hectare, depending upon the degree of acidity. S is becoming deficient in our soils due to use of urea and DAP. As S is an ingredient of essential amino-acids like cystine and methionine, S deficiency results in lowering the yields of cotton. Responses to 20-40 kg S application per hectare are obtained. Deficiency of Mg results in reddening of leaves, while Fe and Mn deficiency leads to the chlorosis of leaves. Zn and B deficiencies lead to the problem of improper bud and boll opening and subsequently to boll rooting. In case of deficiencies of these nutrients, Mg can be given as 1% MgSO_4 foliar spray while others can be given as 0.3-0.5% sulphates of Fe, Mn or Zn or 25-50 kg sulphates of these per hectare to soil. In case of B deficiency, B can be applied to cotton as 0.1% B as boric acid. Lighter soils show greater problems of S and micronutrients.

At Nagpur, sorghum, cotton and pigeonpea, common crops of the region, were grown as sole crops as well as intercropped with soybean giving recommended doses of fertilizers to main crops and no fertilizer to intercropped soybean. It was observed that intercrops, though removed more nutrients from the soil, utilized the applied nutrients more efficiently. Application of FYM along with chemical fertilizers was found more beneficial in improving the crop yields and maintaining better soil health in the cropping systems. In rice fallows of south, short duration cotton varieties can be grown immediately after rice. P and K applied to rice also meet the needs of these nutrients of cotton. Hence, only N is to be applied to cotton following rice.

Also seed treatment with biofertilizers viz. *Azotobacter*, *Azospirillum*, and Phosphorous Solubilizing Bacteria (PSB) @ 25 g/kg of seed is helpful. For seed treatment a paste of fungicides/ biofertilizer should be prepared enough thick, which cover the seeds and these seeds dried in shade. After completely dried seeds should be used for sowing.

At the time of square formation and 30 days after square formation spraying of 2% diammonium phosphate should be carried out for better boll development. For 1 ha of area 8 kg DAP is used and solution is prepared in 400 l of water and sprayed.

Plant protection

In case of, excessive vegetative growth boll removes growing point of main branch and leaves of lower branches alternatively after 70-80 days. Due to this there is aeration and bolls are not rotten and less incidence of insect and diseases of cotton.

Jassids and aphids (nymphs and adults) found on the underside of the leaves, sucking the sap; leaves turn yellow and start curling; in severe cases the leaves turn chocolate red and crumple; in such cases, the growth of plant is also stunted. Sow resistant varieties; spray the crop fortnightly with 0.02% Phosphamidon, Monocrotophos, Methyl demeton, Dichlorros or Dimethoate, starting with the appearance of the pest; 2-3 sprayings may be necessary. American Bollworm is a destructive pest. Caterpillar bore into square flowers and boll and feed within the boll. While feeding head of caterpillar is inside the square or boll and remaining portion is outside the square and boll. When infestation is seen spray following pyrethroids per hectare in 500 l of water -Cypermethrin 25%- 200ml or 10%-500ml or Decamethrin 2.8%- 400ml or 20%- 250ml. If there is infestation of whitefly and jassids do not spray systemic pyrethroids but spray monocrotophos 830ml in 500 l of water. Also collect fallen squares, flowers and bolls and burn it immediately. If American bollworm is not controlled after spraying of insecticides, spray Heliothis, NPV 450 L.E. per hectare and collect caterpillars and destroy it. Red cotton bug (nymphs and adults) suck the sap from the flowers, buds and bolls and taint the lint with faeces. The infested bolls open badly and the quality of the lint is further affected. Spray 0.04% Monocrotophos or Quinolphos Cotton leaf roller (caterpillars) roll the cotton leaves and feed within; exotic varieties are more susceptible; moths, medium sized with yellow wings; active from mid July to September. Hand-picking and destruction of rolled leaves with larvae within; spray 0.1% Carbaryl or 0.04% Monocrotophos; repeat, if necessary.

Seed treatment of fungicides should be given @ 3 gram per kg of cottonseeds. These seeds are dried in shade. After completely dried seeds should be used for sowing. In Anthracnose all the above ground parts of the plant are attacked; infection on the seedlings and bolls is serious; large red spots appear on the seedlings; later, they girdle the stem and kill it. Treat the seed with any organo-mercurial (Agrosan GN, Ceresan) @ 2-2.5 g/kg; spray the crop with 1% Bordeaux mixture. Leaf spots are light brown, circular and numerous, the centre of the spot later turns ashy and falls off, leaving a hole; rusty brown spots of irregular size and shape are observed. Spray the crop with 0.3% fixed copper or 0.2% Zineb. Powdery mildew (white powdery patches) appear on the undersurface of the leaves; the corresponding upper portions just above patches become pale and brown. Dust the crop with finely powdered sulphur @ 15 kg per ha.

Drip Irrigation

Drip irrigation is well suited for water scarce areas of the central zone States and for advancing the cropping season from June-July to April-May. Drip irrigation combined with fertigation is seen to enhance the yield

by 25% over control. The reasons attributed for increases in yield are proper air water balance maintained in soil and hence plant do not suffer from stress, plant growth is faster, continuous and vigorous, shortening of the growing season and early maturity of crop allows higher cropping intensity, lesser weed and pest problems, and greater retention of squares and bolls. The major limitation in the adoption of drip irrigation appears to be the frequent and unprecedented monsoon storms. In areas of scarce water resources and excellent crop production prospects with hybrids cotton, drip irrigation system can be adopted.

The practice of applying liquid fertilizers at optimum levels and in split doses along with irrigation water through drip system will be the most efficient system for integrated irrigation and nutrient management. The extensive adoption of this technique is advocated in high yielding situations under hybrid cotton cultivation in central and southern states. Cropping practice of horsegram, indigo and minor millets in *desi* cotton as well as *hirsutum* cotton is being practiced by farmers in Madurai, Ramnad, Tirunelveli and Tuticorin districts of southern Tamil Nadu.

The Government of Maharashtra has taken initiative to set up a model farm for mechanized agriculture for cotton with special emphasis on drip irrigation and fertigation. This model farm has become the focal point of attraction not only to the cotton farming community of Maharashtra (Raichur) the performance of cotton in drip irrigation demonstration farms is very encouraging. Thus, this modern irrigation practice and fertilization may be pivoted to farm mechanization and more relevant to the Agriculture Engineers to involve in.

Plant Growth Regulators

The effect of Mepiquat Chloride in conferring drought tolerance has also been reported. Naphthalene Acetic Acid (NAA) at 40 ppm has been suggested to prevent early shedding of squares and help in retention of early-formed bolls. Foliar sprays of Ascorbic acid and triacontanol have also been reported to have positive effects on growth and prevention of boll shedding. A spray of 80 ml Cycocel per hectare at 80 days after sowing was seen to increase seed cotton yield by 20%. Application of Dropp at 150 g/ha in 600 liters of water during 60% boll bursting stage in North India increased the number of opened bolls by 40-45% with no adverse effect on the quality of cotton. To avoid shedding of square, flower and bolls of cotton spraying of naphthlaic acetic acid (planofix) @ 1 ml in 4.5 litre soft water should be done at the time of square formation. Second spraying should be carried out 15-20 days after first spraying.

Some Futuristic cotton

As concerns have increased about the health, environmental and pest resistance problems caused by the synthetic chemical inputs, and profitability is often in question, companies have responded by promoting genetically engineered cotton, which is claimed to be 'environmentally safe'. Two types of genetically engineered cotton have been introduced in the past few years: *Bt*-cotton, which contains a gene that enables the plant to produce its own pest-killing toxin, and herbicide-resistant cotton which has been developed to tolerate specific herbicides, glyphosate and bromoxynil. Both types come with their own set of problems.

Bt Cotton: *Bacillus thuringiensis* (*Bt*) is a naturally occurring soil bacterium that has been used safely as a biological pesticide by both conventional and organic farmers for many years. Scientists have taken a gene that produces an insect toxin from the bacterium and inserted it into cotton plants. These plants and their offspring then produce their own *Bt* toxin. *Bt* cotton ('Bollgard') has been developed and produced by Monsanto. In 1996, *Bt* cotton was grown on a commercial scale for the first time in the United States.

There are two major concerns about *Bt* cotton. First, that pests will develop resistance to *Bt* toxin, and secondly that the *Bt* gene will become established in wild relatives of *Bt* crops. The use of natural *Bt* exposes insects to the toxin only when it is applied and resistance has developed only rarely. But insect pests feeding on transgenic *Bt* crops are exposed to toxins continuously and are likely to evolve resistance quickly. Infestations exceed economic thresholds, spraying might be necessary. *Bt* toxins in sprays, now

commonly used by both organic and conventional farmers, would become ineffective and farmers would lose an important pest management tool. Where *Bt* crops are grown near the crop's wild relatives, it is highly likely that the *Bt* gene will transfer to the wild populations as a result of the movement of pollen from the crop to the relatives. This could pose a serious threat especially in centres of diversity. For instance, the resultant wild plants may produce enough *Bt* to ward off insects that normally feed on them which could have implications for natural ecosystems. In some cases, the new gene may strengthen the wild plant, allowing it to become a weed in farmers' fields. With the *Bt* advantage, some plant populations may be able to displace other plants in natural ecosystems, altering local biological diversity. There has been little research in this area.

Herbicide-tolerant cotton: Herbicide-tolerant cotton is a cotton plant that has been genetically engineered to be resistant to a herbicide that would kill a normal cotton plant. As a result, the herbicide can be applied while the plant is growing to control broadleaf weeds without killing the cotton plant itself. Developers of these plants claim that by making cotton plants resistant to specific herbicides, overall herbicide use will decline.

Rhone-Poulenc and Calgene (a biotechnology company) have jointly developed the bromoxynil-tolerant cotton that is currently available to farmers. Bromoxynil is a toxic herbicide produced by Rhone-Poulenc with numerous adverse health and environmental effects. It causes cancer and birth defects in laboratory mammals and is toxic to fish and plants. In May 1998, the United State Environment Protection Agency (EPA) approved the use of bromoxynil on cotton, including genetically engineered cotton.

Glyphosate (Roundup) is a broad-spectrum herbicide used to kill weeds. Roundup is the world's largest-selling agricultural chemical and is estimated to account for up to 17 per cent of Monsanto's total sales. The first commercial season for Roundup Ready (a glyphosate-resistant cotton) was 1997. It appears that the abnormal cotton boll development was not detected under the USDA's oversight programme when transgenic crops are tested to ensure that they are safe for agriculture and the environment before allowing them to be commercialized. Monsanto dominates the market in genetically engineered cotton with its Bollgard and Round-up Ready varieties. Genetic engineering is being promoted as the route to expand and sustainable production. Under the terms of their contracts, farmers are required to pay license fees and are not able to save their seed for following seasons. In addition to the many problems associated with the herbicides themselves, there is a danger that the genes for herbicide tolerance from the crops could be transferred to closely related weeds growing nearby. Such a development would make controlling weeds even more difficult for farmers than it is now.

Organic cottons: Prospective growers should be aware that growing organic cotton is not quite the lucrative proposition it sounds and that there may be more money made, and less risk involved, in growing other crops instead. Cotton has many pests that must be controlled without conventional pesticides under an organic system. Weed control options are limited to those done without synthetic herbicides. Defoliation can be a major challenge, with limited options to accomplish the task. Transitioning from conventional crop production to organic cotton is fraught with risk, not to mention that the transition process takes three years before the fields can be certified as organic. Additionally, in the absence of institutional support and infrastructure, organic growers are unable to move organic cotton around as easily as do conventional growers. Markets for organic cotton are limited, and demand plus foreign supplies influence prices. With heliothis/ weevil eradication programs, however, organic Cotton may have a better chance than before to produce well throughout the Cotton Belt.

Herein it is attempted to describe some of the problems associated with the current dominant cotton production system. In the search for safer, healthier and more profitable alternatives to the cotton production system, the organic option is a way forward.

Yield gap bridging**Prioritized cultural options for bridging yield gap in rainfed cotton are -**

State	District	Yield gap (%)	Prioritised Options	Average Yield (kg/ha)	Expected Yield (kg/ha)
Andhra Pradesh	Adilabad	89	Efficient use of surplus water for supplement irrigation and improved management practices	110	130 to 135
	Guntur, Prakasam	58	Adoption of better management practices including high yield cultivars, Pest and disease management technologies etc...	410	470 to 490
	Kurnool	77	Adoption of <i>in situ</i> water management technologies	206	230-250
Gujarat	Ahmedabad	86	Adoption of better management practices including high yield cultivars, Pest and disease management technologies etc... Adoption of <i>in situ</i> water management technologies	137	165-170
	Bharuch Baroda	75	Efficient use of surplus water for supplement irrigation and improved management practices	250	300 to 315
	Mehasana	73	Adoption of better management practices including high yield cultivars, Pest and disease management technologies etc... Adoption of <i>in situ</i> water management technologies	225	270 to 280
	Surendranagar	77	Adoption of <i>in situ</i> water management technologies	206	230-250
Karnataka	Belgaum	73	Improvement in yield through water harvesting and improved management practices	270	325 to 340
	Dharwad	86	Adoption of better management practices including high yield cultivars, Pest and disease management technologies etc... Adoption of <i>in situ</i> water management technologies	140	165 to 170
	Raichur	81	Adoption of better management practices including high yield cultivars, Pest and disease management technologies etc...Adoption of <i>in situ</i> water management technologies	185	220 to 230
Madhya Pradesh	Shimoga	75	Efficient use of surplus water for supplement irrigation and improved management practices	250	300 to 315
	Dewas	87	Efficient use of surplus water for supplement irrigation and improved management practices	135	160 to 165
	Khandwa	89	Efficient use of surplus water for supplement irrigation and improved management practices	110	130 to 135
	Khargone	86	Adoption of better management practices including high yield cultivars, Pest and disease management technologies etc... Adoption of <i>in situ</i> water management technologies	140	165 to 170

State	District	Yield gap (%)	Prioritised Options	Average Yield (kg/ha)	Expected Yield (kg/ha)
Maharashtra	Akola, Aurangabad Buldhana, Jalgaon Nanded, Parbhani	86	Adoption of better management practices including high yield cultivars, Pest and disease management technologies etc... Adoption of <i>in situ</i> water management technologies	140	165 to 170
	Amaravati	89	Efficient use of surplus water for supplement irrigation and improved management practices	110	130 to 135
	Nagpur, Wardha Yavatmal	87	Efficient use of surplus water for supplement irrigation and improved management practices	135	160 to 165
	Chandrapur Jalna	88	Improvement in yield through water harvesting and improved management practices	115	140 to 145
	Dhule	81	Adoption of better management practices including high yield cultivars, Pest and disease management technologies etc... Adoption of <i>in situ</i> water management technologies	185	220 to 230
Tamil Nadu	Virudhnagar	88	Improvement in yield through water harvesting and improved management practices Adoption of better management practices including high yield cultivars, Pest and disease management technologies etc... Adoption of <i>in situ</i> water management technologies	115	140 to 145

Popular and Botanical Names of Some Rainfed Crops

Arhar (Redgram)	<i>Cajanus cajan</i> (L.) Millsp.
Bajra (Pearlmillet)	<i>Pennisetum americanum</i> (L.) Leeke
Barley	<i>Hordeum vulgare</i> L.
Bengalgram (Gram; Chickpea)	<i>Cicer arietinum</i> L.
Blackgram (Urd)	<i>Vigna mungs</i> (L.) Hepper
Blue panic	<i>Panicum antidotale</i>
Castor	<i>Ricinus communis</i> L.
Chilli	<i>Capsicum frutescens</i> L.
Clusterbean (Guar)	<i>Cyamopsis tetragonolobus</i> (L.) Taub
Coriander	<i>Coriandrum sativum</i> L.
Cowpea	<i>Vigna unguiculata</i> (L.) Walp
Finger millet (Ragi)	<i>Eleusine coracana</i> (L.) Gaertn
Foxtail millet (<i>Setaria</i> , Italian millet)	<i>Setaria italica</i> Beauv
Gingelly (Sesamum, Sesame, Til)	<i>Sesamum indicum</i> L.
	<i>Sesamum orientale</i> L.
	<i>Cicer arietinum</i> L.
	<i>Vigna radiata</i> (L.) Wilczek
	<i>Arachis hypogaea</i> L.
	<i>Cyamopsis tetragonolobus</i> (L.) Tabu
	<i>Macrotyloma uniflorum</i> (Lam.) Verdc
	(<i>Pennisetum purpureum</i> x <i>P. typhoides</i>) F1
	<i>Lablab purpureus</i> (L.) Sweet
	<i>Brassica campestris</i> L.
	<i>Citrus fistulosus</i>
	<i>Setaria italica</i> Beauv
	<i>Sorghum bicolor</i> (L.) Moench
	<i>Corchorus capsularis</i> L.
	<i>Cicer arietinum</i> L.
	<i>Lens culinaris</i> Medic
	<i>Zea mays</i> L.
	<i>Hibiscus Sabdariffa</i> L.
	<i>Vigna aconitifolia</i> (Jacq.) Marechal
	<i>Brassica juncea</i> Coss.
	<i>Pennisetum purpureum</i>
	<i>Guizotia abyssinica</i> (L.f.) Cass
	<i>Oryza sativa</i> L.
	<i>Arachis hypogaea</i> L.
	<i>Pennisetum americanum</i> (L.) Leeke
	<i>Pisum Sativum</i> L.
	<i>Cajanus cajan</i> (L.) Millsp.
	<i>Solanum tuberosum</i> L.
	<i>Panicum miliaceum</i> L.
	<i>Eleusine coracana</i> (L.) Gaertn
	<i>Brassica campestris</i> L.var. Sarson Prain
	<i>Brassica juncea</i> (L.) Czern. & Coss
	<i>Cajanus cajan</i> (L.) Millsp
	<i>Oryza sativa</i> L.
	<i>Hibiscus sabdariffa</i> L.
	<i>Carthamus tinctorius</i> L.
	<i>Brassica campestris</i> L. var. Sarson Prain
	<i>Sesamum indicum</i> L.
Gram (Bengalgram)	
Greengram (Moong)	
Groundnut (Peanut)	
Guar (Cluster bean)	
Horsegram	
Hybrid Napier	
Indian bean (Lablab)	
Indian rape (Toria)	
Indian squash melon (Tinda)	
Italian millet (Foxtail millet, <i>Setaria</i>)	
Jowar (Sorghum)	
Jute	
Kabuli gram	
Lentil (Masoor)	
Maize	
Mesta (Rozella)	
<i>Moth</i> (<i>dew gram</i>)	
Mustard (Raya)	
Napier Grass	
Niger	
Paddy (Rice)	
Peanut (Groundnut)	
Pearlmillet (Bajra)	
Peas	
Pigeonpea (Arhar, Redgram, Tur)	
Potato	
Proso millet	
Ragi	
Rapeseed (Sarson)	
Raya (Mustard)	
Redgram (Pigeonpea, Arhar, Tur)	
Rice (Paddy)	
Rozella (Mesta)	
Safflower	
Sarson (Rapeseed)	
Sesame (Sesamum, Gingelly, Til)	

Setaria (Foxtail millet, Italian millet)	<i>Setaria italica</i> Beauv
Siratro	<i>Macroptilium purpureum</i> L.
Sorghum	<i>Sorghum bicolor</i> (L.) Moench
Soyabean or Soybean	<i>Glycine max</i> (L.) Merr
Sunflower	<i>Helianthus annuus</i> L.
Sweet Potato	<i>Ipomea batatas</i> (L.) Lam
Taramira (Rocket salad)	<i>Eruca sativa</i> Mill
Til (Gingelly, Sesamum, Sesame)	<i>Sesamum indicum</i> L.
	<i>Sesamum orientale</i> L.
Tinda (Indian Squash Melon)	<i>Citrulus fistulosus</i>
Tobacco	<i>Nicotiana tabacum</i> L.
Toria (Indian rape)	<i>Brassica campestris</i> var toria Duthie & Fuller
Tur (Redgram, Pigeonpea, Arhar)	<i>Cajanus cajan</i> (L.) Millsp.
Triticale	<i>Triticale officinale</i>
Urd (Blackgram)	<i>Vigna mungo</i> (L.) Hepper

Generic and Brand Names of Some Pesticides

Herbicides/ Weedicides

ALACHLOR 10G, 50% EC: Lasso (Monsanto), Alataf (Rallis)

ANILOPHOS 30% EC: Aerozin (Agr. Evo), Sumo (Dupont), Glyphotox (AIMCO), Ricil (De'Nocil), Anilostar (Shaw Wallance), Aniloguard (Gharda)

ATRAZINE 50% W.P.: Atrataf (Rallis), Solaro (Pesticides Inida), Dhanusine (Dhanuka)

BENTHIOCARB/ THIOBENCARB 50% EC & 10% Gr: Saturn (Pesticides India), Thiobencarb (Tropical Agro)

BUTACHLOR 50 EC, 5 GR.: Machete (Monsanto), Teer (Rallis), Milchlор (Montari), Wid Kil (Sudarshan Chemicals), Aimchlор (AMICO), Nirmool (Lupin), Starchlor (Shaw Wallace), Dhanuchlor (Dhanuka), Speclor (Southern Pesticides), Hiltaklor (Hindustan Insecticides), Trapp (Searle India), Delchlор (Coromandel Indag), Bilchlор (Bayer)

DIURON 80%: Karmex (Agromore), Mermer, Hexuron (Parry Chemicals)

FLUCLORALIN 45%: Basalin (BASF)

ISOPROTURON 75%, 50% W.P.: Nocilon (De Nocil), Rakshak (Lupin), Milron (Montari), Dhanuron (Dhanuka), Hilproturan (Hindustan Insecticides), Arelon (Agr Evo), Graminon (Novartis), Bilron (Bayer)

METALACHLOR 50% EC: Duel (Novartis)

NITROFEN 8 G, 25%, 24%: Tok-E-25 (Indofil)

OXADIAZON 25% EC: Ronstar (Rhone-Poulenc)

OXYFLOURFEN 23.5%, 0.35 Gr: Goal (Bayer), Oxygold (Indofil)

PENDIMETHALIN 20 & 30% EC, 5% Gr: Stomp (Cyanamid Agro), Panida (Rallis)

SIMAZINE 50%: Tafazine (Rallis), Gesatop, Hexazine (Parry Chemicals)

TRIFLURALIN 48%: Treflan (De'Nocil), Triflurex (Parry Chemicals)

Insecticides

ALDICARB: Temic 10 G (Rhone Poulenc)

CARBARYL: 5% DUST; 10% DUST; 4 G; 50% WP: Parryvin 50 WP (E.I.D. Parry), Dhanuvin 50 WP (Dhanuka), Killlex Carbaryl (Paushak), Hexavin (Parry Chemicals), Kildiryl (Kilpest), Agroryl (Gujarat Agro), Sevin Flo 42%, Sevin 50% WP, Sevin D, Sevidol 4:4G, Sevin 4G (Rhone Poulenc)

CARBOFURAN 3 G, 50% SP: Furadan 3G (Rallis), Furacarb (AIMCO), Carbocil 3G (De'Nocil), Diafuran 3G (Pesticides India), Fury (NFCL), Hexafuran (Parry Chemicals), Furatox (AIMCO), Agroduration (Gujarat Agro)

CARBOSULPHAN 25% DS: Marshal (Rallis)

CHLORPYRIPHOS 20 EC, 10 G, 1.5 DP: Coroban (Coromandal Indag), Blaze (Indofil), Dursban, Ruban (De'Nocil), Sulban (Sulphur Mill), Specphos 20 (Southern Pesticides), Hyban (Hyderabad Chemicals), Radar (Searle India), Nuklor 20EC (Dupont), Corocin (IOCL), Scout (AIMCO), Dhanwan 20 (Dhanuka), Durmet 20EC (Cyanamid Agro), Classic (Lupin), Starban (Shaw Wallace), Doomer (Bhaskar Agro), Hilban (Hindustan Insecticides), Tagban 20 EC (Tropical Agro), Cyphos (ICI-Zenica), Tarkash (BASF), Force (NFCL), Pyrivol (Voltas), Hexaban (Parry Chemicals), Agro-Chlore (Gujarat Agro), Chlorguard (Gharda), Tafaban (Rallis), Strike (Wockhardt), Robust (Sabero)

CYPERMETHRIN 10 EC: Ralothrin (Rallis), Ankush (BASF), Simper (ICI-Zeneca), Hi-Power (Sulphur Mills), Spec Cyperin (Southern Pesticides), Hycyper (Hyderabad Chemicals), Cyper Top (Thakar Chemicals), Lacer (Searle India), Agro-Cyper (Gujarat Agro), Jawa (Dupont), Cypercine (IOCL), Super Killer (Dhanuka),

Cypermil (Montari), Polytrin (Novartis), Cyproid (AIMCO), Challenger (Tropical Agro), Cilcord, (De'Nocil), Starcip (Shaw Wallace), Volcyper (Voltas), Cypermar (Parry Chemicals), Hilcyperin (Hindustan Insecticides),

CYPERMETHRIN 25 EC: Cymbush (ICI-Zeneca), Ralothrin (Rallis), Cypersul (Sulphur Mills) Spec Cyperin (SPEC), Angel (Hyderabad Chemicals), Cyper Top (Thakar Chemicals), Trofy 25 EC (Searle India), Cypercine (IOCL), Challenger (Tropical Agro), Cypermil (Montari), Cyperguard (Gharda Chemicals), Polytrin (Novartis), Cyproid (AIMCO), Clicord (De'Nocil), Colt-25 (Pesticides India), Volcyper (Voltas), Shakti (Lupin), Basathrin (BASF), Hilcyperin (Hindustan Insecticides), Cybil (Bayer), Cyrex (United Phosphorus), White Gold (Newchemi), Panther (Bhaskar Agro Chemicals), Blaze (Indofil), Super Killer (Parry Chemicals), Starcip (Shaw Wallace), Super Killer (Dhanuka), Baadha (Sabero)

DIAZINON 20 EC, 10% Gr: Basudin (Novartis), Tik-20 (Rallis)

DICHLOROVOS 76 EC: Nuvan (Novartis), Vapona (De'Nocil), Suchlor (Sudarshan Chemicals), Specvos (SPEC), Dicotop (Thakar Chemicals), Amidos (AIMCO), Doom (United Phosphorus), Luvon (Lupin), Hilfol (Hindustan Insecticides), Divap 100 (Pesticides India), Marvex Super (Parry Chemicals), Agro-DDVP (Gujarat Agro), Vantaf (Rallis)

DICOFOL 18.5 EC: Kelthane (Bayer), Difol (Sulphur Mills), Hi Might (SPEC), Dilop (Thakar Chemicals), Tik-Tok (United Phosphorus), Hilfol (Hindustan Insecticides), Hycofol (Hyderabad Chemicals), Hexakil (Parry Chemicals), Dhanuka Dicofol (Dhanuka), Colonels (Indofil)

DIMETHOATE 30 EC: Tafgor (Rallis), Tara-909 (Shaw Wallace), Specgor (Southern Pesticides), Hygro (Hyderabad Chemicals), Tophoate (Thakar Chemicals), Parrydimate (EID Parry) Diadhan (Dhanuka), Milgor (Montari), Dimetox (AIMCO), Nugor (United Phosphorus), Primer (Bhaskar Agro), Tagor (Tropical Agro), Teeka (NFCL), Champ (Searle India), Hexagor (Parry Chemicals), Hilthoate (Hindustan Insecticides)

ENDOSULFAN 35 EC & 4% D, 2% D: Thiodan (Agro Evo), Endocel (Excel), Endosul (Sulphur Mills), Endostar (Shaw Wallace), Dawn (Southern Pesticides), Hysulfan (Hyderabad Chemicals), Top Sulfan (Thakar Chemicals), Endocin (IOCL), Parry Sulfan (E.I.D. Parry), Endodhan (Dhanuka), Endonil (Montari), Endosol (AIMCO), Thiokill (United Phosphorus), Lusulfan (Lupin), Agro Sulfan (Gujarat Agro), Hildan (Hindustan Insecticides), Tagsulfan (Tropical Agro), Hexasulfan (Parry Chemicals), Endotaf (Rallis), Speed (NFCL), Devigor (Devi Dayal)

FENITROTHION: Sumithion (Rallis), Folithion (Bayer), Hexafen (Parry Chemicals)

FENVALERATE 20 EC 0.4% DUST: Fenval (Searle India), Bilfen (Bayer), Starfen (Shaw Wallace), Fen-Fen (Parry Chemicals), Topfen (Thakar Chemicals), Tagfen (Tropical Agro), Trump Card (Dhanuka), Hilfen (Hindustan Insecticides), Fencron (Novartis), Sumitox (AIMCO), Fenkill (United Phosphorus), Lufen (Lupin), Starfen (Shaw Wallace), Agrofene (Gujarat Agro), Bhaskarfen (Bhaskar Agro), Newfen (Gharda), Fenkem (New Chemi), Anchor (ICI-Zeneca), Fenny (NFCL), Viper (SPEC), Milfen (Montari), Tatafen (Rallis), Fennock 20 (De'Nocil), Bhasma (Wockhardt)

FIPRONIL 0.3% Gr, 5% SC: Regent (Rhône – Poulenc), Tempo (Agr Evo)

FORMOTHION 25%: Anthio (Novartis)

LINDANE (GAMMA-B.H.C.) 1.3%, 20%EC: Higama (SPEC), Lintox (AIMCO), Lindstar (Shaw Wallace), Lintaf (Rallis)

MALATHION 50 EC: Dhanuka Malathion (Dhanuka), Cythion (Cyanamid Agro), Sulmathion (Sulphur Mills), Specmal (SPEC), Agromala (Gujarat Agro), Malatop (Thakar Chemicals), Himala (Hindustan Insecticides), Malamar (Parry Chemicals), Luthion (Lupin), Malataf (Rallis), Maltax (AIMCO)

MONOCROTOPHOS 36% SL: Nuvacron (Novartis), Monocil (De'Nocil), Monovol (Voltas), Atom (Indofil), Sufos (Sudarshan Chemicals), Monostar (Shaw Wallace), Specron (Southern Pesticides), Hycrophos (Hyderabad Chemicals), Topcil (Thakar Chemicals), Monocin (IOCL), Monochem (New Chemi), Parryphos (EID Parry), Milphos (Montari), Monodhan (Dhanuka), Phoskill (United Phosphorus), Lumphos (Lupin), Kadett

(PesticidesIndia), Agromonark (Gujarat Agro), Moncar (Bhaskar Agro), Azodrin (Cyanamid Inida), Hilcron (HindustanInsecticides), Macrofos (Tropical Agro), Croton (Searle India), Balwan (Rallis), Monophos (Parry Chemicals), Monocron (NFCL), Corophos (Coromandel Indag), Bilphos (Bayer), Monosect (Arg Evo)

METHYL-PARATHION 50 EC: Metacid (Bayer), Parataf (Thakar Chemicals), Dhanumar (Dhanuka), Milion (Montari), Paratox

(AIMCO), Luthion (Lupin), Devithion (Devidayal), Tagpar (Tropical Agro System), Paramar M. (Parry Chemicals), Agro-Para (Gujarat Agro), Parataf (Rallis)

METHYL-PARATHION DUST 2%: Folidol (Bayer), Parataf (Sulphur Mills), Dhanudol (Dhanuka), Paratox (AIMCO)

OXY-DEMETON METHYL 25 EC: Metasystox (Bayer), Hexasystox (Parry Chemicals), Dhanusystox (Dhanuka), Mode (Agr Evo)

PHORATE 10 G: Thimet (Cyanamid Agro), Foratox (Pesticides Inida), Volphor (Volrho), Starphor (Shaw Wallance), Specphor (SPEC), Forcin (IOCL), Dhan 100 (Dhanuka), Milate (Montari), Granutox (AIMCO), Umet (United Phosphorous), Luphate (Lupin), Agro-Phorate (Gujarat Agro), Helmet (Tropical Agro Chemicals), Warrant (Searle India), Hilphorate (Hindustan Insecticides), Grenades

PHOSALONE 35% EC & 4% Dust: Zolone (Rhône-Poulenc), Voltas Phosalone (Voltas)

PHOSPHAMIDON 85 S.L.: Dimecron (Novartis), Cildon (De'Nocil), Sumidon (Sudershan Chemicals), Hydan (Hyderabad Chemicals), Topcron (Thakar Chemicals), Aimphon (AIMCO), Umeson (United Phosphorous), Phamidon (Lupin), Agromidon (Gujarat Agro), Hawk (Hindustan Insecticides), Specmidon (SPEC), Rilon (Rallis)

QUINALPHOS 25 EC: Ekalux AF (Novartis), Quinaltaf (Rallis), Flash (Indofil), Quinal (Sulphur Mills), Suquin (Sudershan Chemicals), Quinguard (Gharda), Starlux (Shaw Wallace), Knock (Southern Pesticides), Hyquin (Hyderabad Chemicals), Ekaton (Thakar Chemicals), Smash (Searle India), Chemlux (New Chemi), Shakti (E.I.D. Parry), Dhanulux (Dhanuka), Quinatox (AIMCO), Kinalux (United Phosphorous), Vazra (Lupin), Agroquin (Gujarat Agro), Basquin (Bhaskar Chemicals), Hilquin (Hindustan Insecticides), Tagquin (Tropical Agro), Quick (NFCL), Volquin (Voltas), Bayrusil (Bayer), Krush (Wockhardt)

TRIAZOPHOS 40% EC: Hostathion, Trelka (Agr Evo)

THIODICARB 75% WP: Larvin (Rhône-Poulenc)

Fungicides

AUREOFUNGIN 46.15% SP: Aureofungin Sol (Hindustan Antibiotics)

CAPTAFOL 80%: Foltaf (Rallis)

CAPTAN 50%, 75% SP: Hexacap (Parry Chemicals), Captaf (Rallis), Dhanutan (Dhanuka), Deltan (Coromandel Indag)

CARBENDAZIM 50 WP, 5 Gr: Barvistin, Subeej (BASF), Zoom (United Phosphorous), Agni (EID Parry), Dhanusten (Dhanuka), Derosal (Agro Evo), Aimcozim (AIMCO), Bengard (De'Nocil), Hycarb (Hyderabad Chemicals), Calzin (Lupin), Benzin (Bhaskar Agro), Benfin (Indofil), Carzim (Lupin), Nirmool (Shaw Wallance), Diafuran (Pesticides India), Stare (Parry Chemicals), Zen (NFCL), Volzim (Voltas), Agrozim (Gujarat Agro), Arrest (Searle)

EDIFENPHOS 50 EC: Hinosan (Bayer)

HEXCONAZOLE 5% EC: Contaf (Rallis)

MANCOZEB 75%: Dithane M-45 (Bayer), Uthane M-45 (United Phosphorous), Luzen (Lupin), Dhauka M- 45 (Dhanuka), Hilthane (Hindustan Insecticides), Shield (Pesticides India), Spic Mancozeb (Spic),

Zeb (NFCL), Manzate (Dapal), Zebthane (Rallis), Luzim (Lupin), Abic M45 (Novartis), Aimcozeb (AIMCO), Agromanco (Gujarat Agro), Indofil M-45 (Indofil), Sparsh (Wockhardt), Saviour (De'Nocil)

PROPICONAZOLE: Radar (Rallis), Tilt (Novartis)

STREPTOCYCLINE: Streptomycin (Hindustan Antibiotics), Plantomycin (Aries Agrovet)

SULPHUR 85 W.P. & DUST: Sultaf (Rallis), Insulf (United Phosphorous), Dhanusulf (Dhanuka), Sulphosan (AIMCO), Thiovit (Novartis), Farmasulf (Shaw Wallance), Microsulf (Parry Chemicals), Sulfin M-20 (Gujarat Agro), Hexasul (Parry Chemicals), Sulcol, Wet-Sulf (Excel).

TRIDEMORPH 80% EC: Calixin (BASF)

THIRAM 75%: Hexathane (Parry Chemicals), Thiride (IEL), Vegfru thiram (Pesticides India)

ZINEB 75% W.D.P.: Hexathane (Parry Chemicals), Discon-Z (AIMCO), Devizeb (Devidayal)

ZIRAM 80% WP, 27% CS: Cuman L. (Novartis), Hexazir (Parry Chemicals), Ziride (IEL), Vegfru Zitox (Pesticides India), Tagziron (Tropical Agro)

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