

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

**District based
Promising Dryland Technologies
for Five Rainfed Oilseed Crops Based
Production Systems in India:
*Castor, Rapeseed Mustard, Safflower,
Soybean and Sunflower***



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

Santoshnagar, Hyderabad 500 059

MAY, 2003

Citation: KPR Vittal, HP Singh, G Ravindra Chary, GR Maruthi Sankar, T Srijaya, JS Samra and Gurbachan Singh. Eds. (2003). District based Promising Dryland Technologies for Five Rainfed Oilseed Crops Based Production Systems in India: Castor, Rapeseed Mustard, Safflower, Soybean and Sunflower. All India Co-ordinated Research Project for Dryland Agriculture, Central Research Institute for Dryland Agriculture, Indian Council of Agricultural Research, Hyderabad 500 059. 160 Pages.

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 oilseed crop region, were identified. The crops are castor, rapeseed mustard, safflower, soybean, and sunflower. Their agro geographic setting, soil and water conservation, crop management including nutrient management, pest management etc., suitable cropping systems, contingency plans, alternate farming systems were 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), but also others from National Agricultural Research System (NARS), Agro-industries and State Department(s) of Agriculture.

Cover: Greening the grey areas

Designed by – I Ram Mohan, KVGK Murthy

*a compendium by AICRPDA, CRIDA,
DOR, NRCRM, NRCS, SAUs, Agro-Industries
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Agro-Industries

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Seeds
Fertilizers
Pesticides

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Karnataka
Madhya Pradesh
Maharashtra
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Rajasthan
Tamilnadu
Uttar Pradesh

Secretarial assistance by

G Varalakshmi

Technical assistance by

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GIS Support by

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Supported by

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INTRODUCTION

In the domestic agricultural sector, oilseeds occupy a distinct position after cereals sharing thirteen per cent of the country's gross cropped area and accounting for nearly five per cent of the gross national product and ten per cent of the value of all agricultural products. India is blessed with diverse agro-ecological conditions ideally suited for growing nine annual oilseed crops, viz., groundnut, rapeseed-mustard, sunflower, sesame, soybean, safflower, castor, linseed and niger; two perennial oilseed crops (coconut and oil palm) besides secondary oil crops such as maize and cotton. In addition to the above, more than 100 tree species of forest origin which have the potential to yield about one million tons of vegetable oil are grown in the country. The major annual oilseed crops growing states are Madhya Pradesh (24.1%), Gujarat (11.6%), Andhra Pradesh (11.5%), Rajasthan (11.4%), Maharashtra (10.9%), Karnataka (9.5%), Uttar Pradesh (6%) and Tamil Nadu (4.5%). Punjab, Haryana, Himachal Pradesh, Bihar, Jammu & Kashmir, West Bengal, Orissa, Kerala and North Eastern states are covering the remaining 2.4 million hectares of oilseed growing areas. Madhya Pradesh (22.5%) also tops the list of major annual oilseed producing states followed by Andhra Pradesh (13%), Maharashtra (11.3%), Rajasthan (11%), Gujarat (9.2%), Tamil Nadu (8.6%), Karnataka (7.5%) and Uttar Pradesh (6%). In India, groundnut ranks first contributing 34% of the total output followed by soybean (29%), rapeseed & mustard (23%), castor 5% and other five-oilseed crops (10.1%).

Dry farming research network started in 1971 was benefited with time by development of appropriate region based recommendations on resource conservation and utilization and tailoring rainfall oilseed based cropping systems through early maturing hybrids and varieties. The international interests in upgrading the productivity and sustainability of the dryfarming regions in Asia, Africa and Latin America also helped in making rapid strides in providing answers to several of the issues in rainfed farming. A new phase of adopting dryfarming recommendations on a holistic mode is the need of the hour to cope with the weather aberrations. Most of the general recommendations even though focused for a agro climatic region, they were lacking in need based focus for holistic production system development of total productivity. Presently, an effort is made to answer the prioritized needs from the recommendations that are available from various State Agricultural Universities and the All India Coordinated Research Project for Dryland Agriculture (AICRPDA) network and other organizations on prioritized mode. Rainfed land is present in almost all agro ecological regions encompassing almost all soil orders, cumulative degradation etc. in several crop based production systems ranging from sole crops, sequence crops through intercropping systems.

The predominant rainfed oilseed crops in the arid, semi-arid and dry sub-humid climatic zones were identified. The States of Andhra Pradesh, Bihar, Chattisgarh, Gujarat, Haryana, Jharkhand, Karnataka, Maharashtra, Madhya Pradesh, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and Uttaranchal mostly cover these regions. The rainfed area is 81, 37, 94, 79, 100, 100, 98 and 97 percent under groundnut, rapeseed mustard, sesame, linseed, castor, safflower, soybean and sunflower respectively. Presently, this compendium revolves around five oilseed crops based production systems, viz. castor, rapeseed mustard, safflower, soybean and sunflower. The changes in area and production during 1961-2001 along with cumulative growth rates are presented in Fig.1 and 2. Compound growth rates for the period of 1991-2001 in both area and production follow :

Fig 1 : Changes in area of oilseed crops during 1961-2001

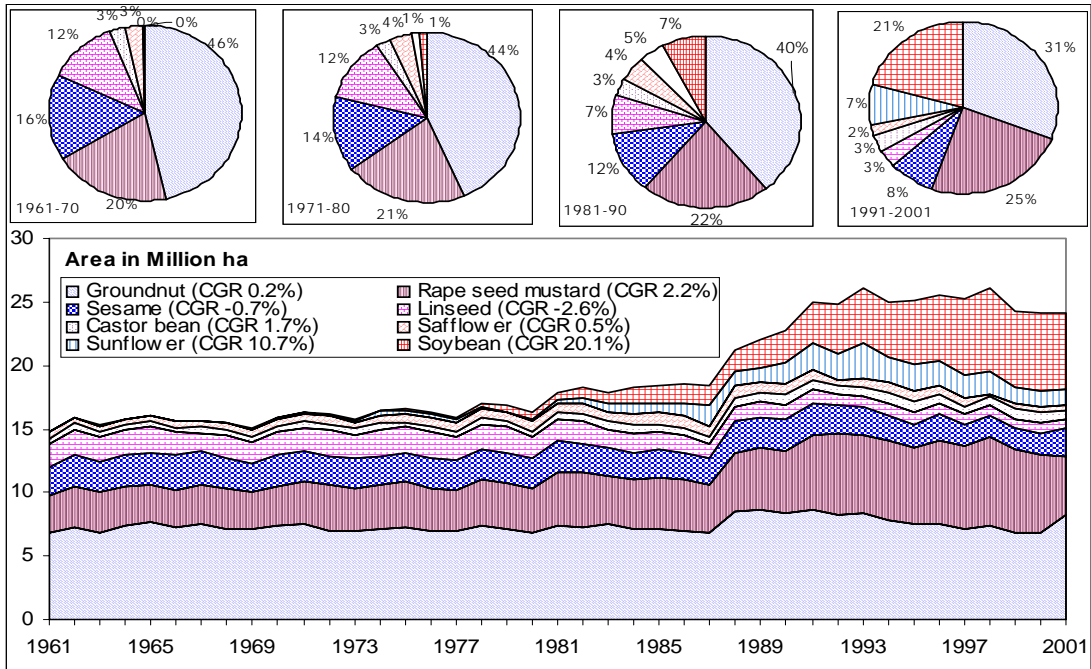
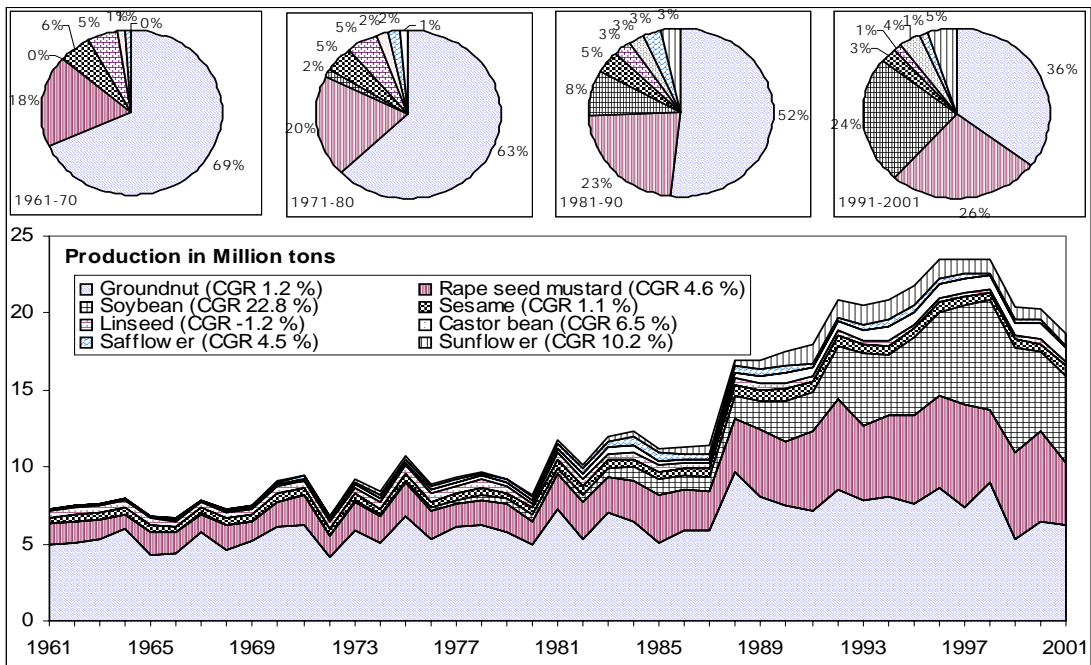


Fig 2 : Changes in production of oilseed crops during 1961-2001



CGR: Cumulative Growth Rate

National Compound Growth Rates 1991-2001 of Oilseeds			
Production Growth Rate	Area Growth Rate		
	Increasing	Stagnant	Decreasing
Increasing	Soybean (981, 1%) Castor (1080, 3.3%)		
Stagnant		Rapeseed Mustard (883, 0.2%)	
Decreasing			Sunflower (568, 0.1%) Safflower (530, 2.3%)

Increasing CGR > +1%; Stagnant CGR -1 to +1%; Decreasing CGR < -1%

In parentheses are average yield, kg/ha and its % growth rate

Cropping region

In the rainfed agriculture, crop diversification for risk reduction is the farmers' weapon against aberrant weather. Thus the crop area distribution is wide spread, but a few districts contain most of the area. The area under districts was arranged according to the area covered in descending order. The districts covering 85% of the oilseed cropped area were selected and recognized as a crop region. Under each of the crops, the priority districts are listed in the later chapters.

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 was made and optimum number of clusters were identified. Based on statistical significance, the yield and area growth rates were defined as increasing, decreasing or stagnant.

Yield gap and surplus index of productivity zones

For these cluster of districts, the surplus index (ratio of runoff to average annual normal rainfall) was calculated by (Thorntwaite and Mather method, 1955). 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:

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

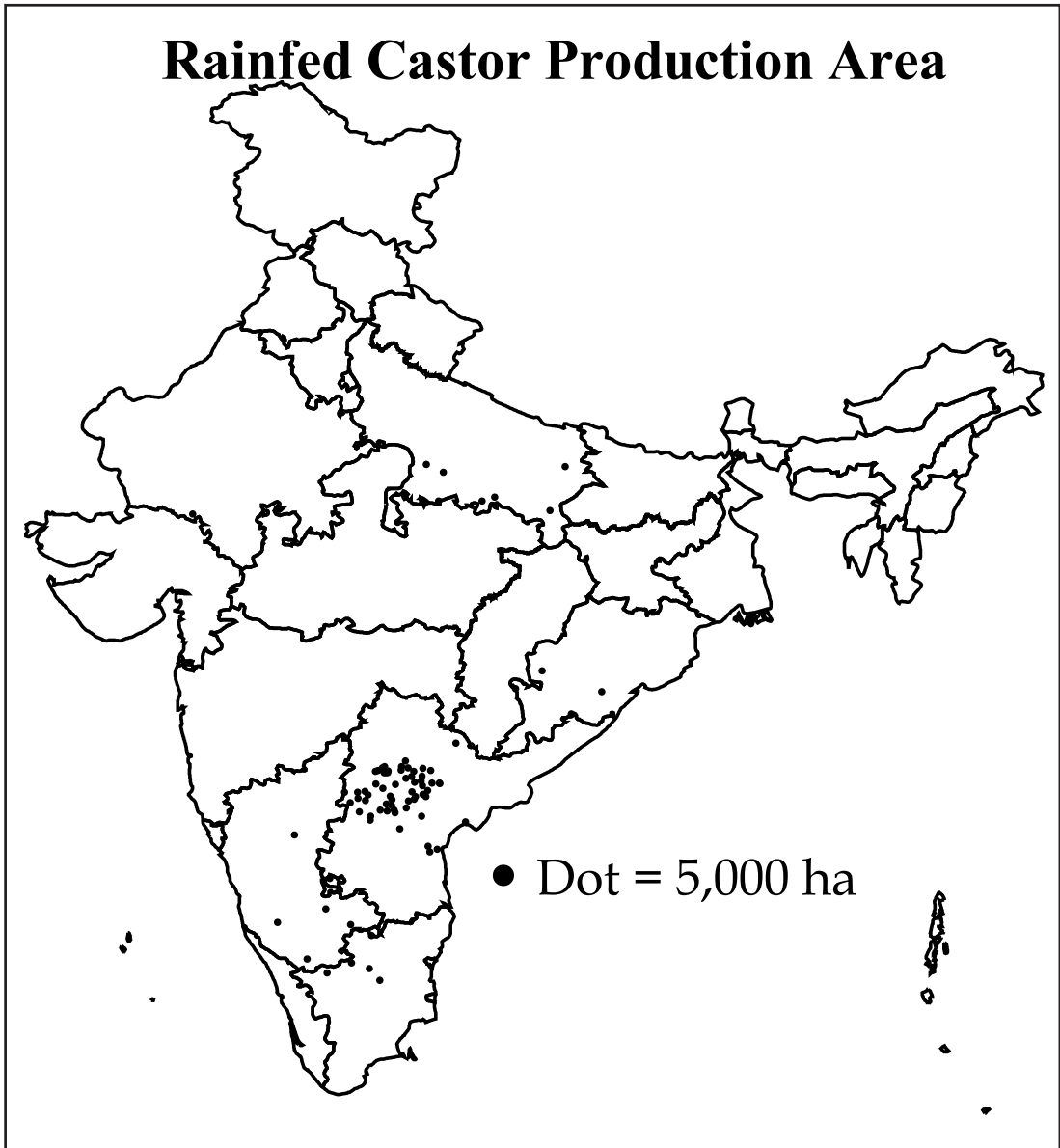
The yield gap between productivity of crop (average yield of 1990-91 to 1994-95 for which period authentic published data is available) and achievable yield (calculated based up on water use efficiency, water requirement and water requirement satisfaction index), was estimated for each district. The average yield gap of cluster was grouped as low (< 33%), medium (33-66 %) and high (>66%). The possible options for productivity enhancement are –

Yield Gap	Possible Options
<33	Non monetary inputs, input management 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 to alternate land uses, contingent crop planning

Recommendations Domain

Strategies were matched with the matrix of surplus index and yield gap of clusters based on above options. Recommendations were derived for these clusters from the nearest research center of National Agricultural Research System (NARS), All India Coordinated Research Project for Dryland Agriculture (AICRPDA) or publications for the region, from state Department of Agriculture and agro-industries.

Recommendations are given for crop based production system, state-wise and cluster(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-geographic setting i.e. climate, physiography, soils, annual rainfall, potential evapo-transpiration (PET) and moisture availability period. The identified priorities for increasing the productivity in short term are also included.



CASTOR BASED PRODUCTION SYSTEM

The main castor-growing countries are Brazil, India, USSR and Argentina. India ranks first in area but second in production, Andhra Pradesh (67.2%), Gujarat (12.7%), Karnataka (7.1%) and Orissa (5.8%) account for over 90% of the area and also production. It is generally grown for its oil-yielding seeds. The oil content of the seeds varies from 35-58% in different varieties, the average being about 47%. Castor oil is being used widely for various purposes. It is used as a lubricant in high-speed engines and aeroplanes, in the manufacture of soaps, transparent paper, printing inks, varnishes, linoleum and plasticizers. It is also used for medicinal and lighting purposes. The cake is used as manure and plant stalks as fuel or as thatching material or for preparing paper-pulp. In the silk-producing areas, leaves are fed to the silkworms.

Castor belongs to the genus *Ricinus*, and is a member of the *Euphorbiaceae* which consists a vast number of plants mostly native to the tropics. The genus *Ricinus* is considered to be monotypic and *Ricinus communis* as the only species, which includes many polymorphic types. According to the available literature, castor is indigenous to Eastern Africa and most probably originated in Ethiopia. The cultivated types are dwarf annuals. The stem is erect, circular in section, partially hollow, smooth, glabrous, with good branching. The stem is marked by a number of well-defined nodes, from each of which a leaf arises. The lower internodes are shorter and their length increases with the height. Leaves are alternate, large, palmate with 5-11 lobes, acuminate, margins notched serrate or indented. They are carried on long stout petioles. The inflorescences are borne terminally on the main and lateral branches. Flowers are large, in terminal sub-paneled racemes, monoecious, apetalous, the upper portion of the raceme being occupied by the female flowers and the lower by the male flowers. The fruit is a roundish glaucous capsule, with three projecting sides covered with tough or smooth spines, three-loculed and three-seeded. Seeds are albuminous, anatropous, broad, oval, compressed with a marked carnele and longitudinal raphe. The testa is thin, brittle, varying in colour and mottling. Below the testa is the thin tegmen, covering the whitish oily endosperm containing the embryo. Varieties differ in the branching habit of the plants, colour of the stem and branches (red and green), the nature of capsules (smooth or shiny), duration (early or late) and the size of seed.

The introduction of hybrids and the management technologies generated has resulted in increased area, production and productivity of castor under irrigated conditions of Gujarat and Rajasthan. In rainfed areas, high yielding and early maturing varieties gave high and stable yields over the years. The increased production helped in earning valuable foreign exchange. This crop was introduced into the non-traditional areas of Rajasthan and coastal Andhra Pradesh in different cropping systems. There is a need for development of wilt resistant hybrids and technology for higher water use efficiency. Castor is grown in 0.45 mha in 202 districts out of which 0.44 mha is rainfed. About 85% of the rainfed area (0.35 mha) is in 12 districts.

Selection Criteria	No. of Districts	Area under Castor ('000 ha)	Area under Rainfed Castor ('000 ha)	Gross Cropped Area ('000 ha)	Yield (kg/ha)
States (16)	202	456	440	109086	263
Agro-ecoregion**	157	420	415	86059	283
Cumulative 85% Rainfed Castor Area	12	352	351	7492	327

** Arid, semiarid and dry sub humid

Growth Rates

The trends in area and yield growth rates for different districts are given in the following table:

Area	Yield	State	District
Stagnant	Increasing	Andhra Pradesh	Nalgonda
Stagnant	Stagnant	Andhra Pradesh	Ranga Reddy
Decreasing	Increasing	Andhra Pradesh	Warangal
Increasing	Increasing	Andhra Pradesh	Mahaboobnagar
Increasing	Stagnant	Tamilnadu	Salem
		Andhra Pradesh	Guntur

Production System is sorghum/pearlmillet-castor in hot semi-arid Northern plains. Details on associated crops and livestock are presented below:

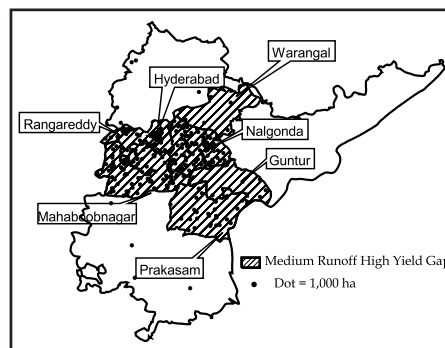
Crops	Animals	Districts
Rice	Male Buffalo	Guntur, Hyderabad, Mahaboobnagar, Nalgonda, Warangal,
Castor	Male cattle	Salem, Hamirpur, Prakasam, Dharmapuri, Ranga Reddy,
Sorghum	Female Buffalo	Kalahandi, Koraput
Wheat	Female Cattle	
Pearlmillet	Sheep	
Pigeonpea	Goat	
Blackgram		
Greengram		
Horsegram		
Fruits		
Vegetables		

The recommendations on this crop based production system are given below state and district-wise in alphabetical order for the regions with low (<12%), medium (12–25%) and high (>25%) surplus index, and low (<33%), medium (33-66%), and high (>66%) yield gap from achievable yield are presented:

Andhra Pradesh

In Andhra Pradesh there are seven districts viz, Guntur, Hyderabad, Mahaboobnagar, Nalgonda, Prakasam, Ranga Reddy and Warangal under Medium runoff and high yield gap.

State	District	Region
Andhra Pradesh	Guntur Hyderabad Mahaboobnagar Nalgonda Prakasam Ranga Reddy Warangal	Medium runoff and high yield gap



Agro-geographic 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 (Orthids – 40%; Vertisols – 30%; Sandy Alfisols – 30%)
- Annual rainfall: 704 mm
- Potential evapotranspiration: 1777 mm
- Moisture availability period: 150-180 days

Hyderabad

- Climate: Hot moist semi arid
- Physiography: North Telangana
- Soils: Deep loamy, clayey mixed red and black soils (Sandy Alfisol – 100%)
- Annual rainfall: 764 mm
- Potential evapotranspiration: 1758 mm
- Moisture availability period: 120-150 days

Mahaboobnagar

- Climate: Hot moist semi arid
- Physiography: North Telangana
- Soils: Deep loamy, clayey mixed red and black soils (Vertisols – 40%; Vertic inceptisols – 20%; Sandy Alfisols – 40%)
- Annual rainfall: 792 mm
- Potential evapotranspiration: 1678 mm
- Moisture availability period: 120-150 days

Nalgonda

- Climate: Hot moist semi arid
- Physiography: North Telangana
- Soils: Deep loamy, clayey mixed red and black soils (Sandy Alfisol – 100%)
- Annual rainfall: 763 mm
- Potential evapotranspiration: 1761mm
- Moisture availability period: 120-150 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 soils – 70%; Orthids – 30%)
- Annual rainfall: 848 mm
- Potential evapotranspiration: 1951 mm
- Moisture availability period: 150-180 days

Ranga Reddy

- Climate: Hot moist semi arid
- Physiography: North Telangana
- Soils: Deep loamy, clayey mixed red and black soils (Sandy Alfisols – 100%)

- Annual rainfall: 829 mm
- Potential evapotranspiration: 1750 mm
- Moisture availability period: 120-150 days

Warangal

- Climate: Hot moist semi arid
- Physiography: North Telangana
- Soils: Deep loamy, clayey mixed red and black soils (Sandy Alfisols – 40%; Vertic inceptisols – 35%; Orthids – 25%)
- Annual rainfall: 925 mm
- Potential evapotranspiration: 1790 mm
- Moisture availability period: 120-150 days

Soil and water conservation

Guntur, Hyderabad, Prakasam, Ranga Reddy

- 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.

Mahaboobnagar, Warangal

- Inter-plot water harvesting of 1:1 cropped to uncropped land

Nalgonda

- Ridges and furrows

Crop management

Guntur, Prakasam

- Varieties: YLM11, T78, Sweta, T11, Deepti, DCH-30, Aruna, Jyothi and Kranthi
- Seed rate: 12 to 15 kg/ha
- Planting pattern:
 - 90x20 cm or 60x30 cm
 - 60x15 cm in case of late sowing
- Nutrient management
 - 20 kg N and 40 kg P₂O₅/ha as basal and 20 kg N/ha each at 35 – 40 and 65 – 70 days after sowing
 - Application of 50% recommended dose of fertilizer + Azospirillum seed treatment + 25% N through FYM gives higher seed yields
 - Green manuring through Subabul at the time of sowing castor to meet 75% of total N requirement.
- Pest management
 - Use light traps on community basis on the onset of monsoon to attract moths and kill them in kerosinised water

- Castor semilooper – Endosulfan 355 E.C, 1.5 to 2 ml/l of water or 50% Carbaryl 3 g/l of water or 40% Monocrotophos 2 ml/l of water
- 36% Monocrotophos 2 ml/l of water within 12 to 15 days after sowing as per need
- The population of capsule borer incidence more than 10% damaged capsules, dust the crop with Quinolphos
- 1.5 D or Methyl Parathion 2% dust @ 25 kg/ha or spray with Monocrotophos 0.04%.

Some other important practices

- *Kharif* – Sowing up to July last week
- Summer – Sowing January second fortnight
- 3 g of Thiram/ Captan per kg of seed
- Tilling the soil up to 20-30 cm depth improves yield in shallow soils
- 60x30 cm spacing
- IPM – Semilooper

Hyderabad, Mahaboobnagar, Nalgonda, Ranga Reddy, Warangal

- Varieties: DCH-32, DCS-1, Sowbhagya, YLM11, T78, Sweta, T11, Deepti, DCH-30, Aruna, Bhagya, VI-9, Jyothi, Kranthi
- Seed rate: 12 to 15 kg/ha
- Planting Pattern:
 - 90x20 cm or 60x30 cm
 - 60x15 cm in case of late sowing
- Nutrient management
 - 20 kg N and 40 kg P₂O₅/ha as basal and 20 kg N/ha each at 35 – 40 and 65 – 70 days after sowing
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 - The population of capsule borer incidence more than 10% damaged capsules, dust the crop with Quinolphos 1.5 D or Methyl Parathion 2% dust @ 25 kg/ha or spray with Monocrotophos 0.04%.

Some other important practices

- *Kharif* – Sowing up to July last week
- Summer – Sowing January second fortnight
- 3 g of Thiram/Captan per kg of seed
- Tilling the soil up to 20-30 cm depth improves yield in shallow soils
- 60x30 cm spacing
- IPM – Semilooper
- Castor with 50,000 plants/ha can take intermediate dry spells during various growth stages.
- Breaking the hard pan below sub soil by deep ploughing

Suitable cropping systems

Guntur, Prakasam

- Castor + sorghum
- Castor + pigeonpea (1:1)
- Castor + cowpea (1:2)
- Castor + blackgram (1:2)
- Castor + greengram (1:2)
- Castor + clusterbean (vegetable) (1:1)
- Castor + groundnut (1:5/ 1:7)
- Castor + horsegram (relay crop) (1:6)

Hyderabad, Mahaboobnagar, Nalgonda, Ranga Reddy, Warangal

- Castor + sorghum
- Castor + greengram/blackgram
- Castor + pigeonpea (2:1)
- Intercropping one row of clusterbean between 90 cm castor rows.
- Blackgram + castor (6:1), castor + setaria and castor + cowpea

2 year rotation

- Castor - pearl millet (1:1)
- Castor - cowpea
- Castor - groundnut
- Castor - sorghum

Farm implements/ tools

Guntur, Hyderabad, Mahaboobnagar, Nalgonda, Prakasam, Ranga Reddy, Warangal

- 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 indica*, *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.

Hyderabad, Mahaboobnagar, Nalgonda, Warangal, Ranga Reddy

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

- Silvipastoral system: *Leucaena leucocephala* + *Stylosanthes hamata*, *Leucaena leucocephala* + *Cenchrus ciliaris*
- Alley cropping: *Leucaena leucocephala* + sorghum / pearl millet, *Gliricidia sepium* + sorghum/pearl millet
- Agri-Horti system: Mango + short duration pulses
- Fruit: Mango, ber, custard apple, guava, pomegranate, amla
- Fodder/green biomass: *Leucaena leucocephala*, *Azadirachta indica*, *Albizia lebbeck*, *Bauhinia purpurea*, *A. procera*, *B.monosperma*, *A.amara*, *D. sissoo*
- Medicinal & Aromatic Plants: *Catharanthus roseus*, *Cassia angustifolia*, *Aloe barbadensis*, *Withia somnifera*, *Cymbopogon martini*, *Cymbopogon flexuosus*, *Vetiveria zizanioides*, *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 crop planning

Hyderabad, Mahaboobnagar, Nalgonda, Ranga Reddy

June: Normal onset of monsoon

- 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: Late onset of monsoon

- Sow castor (Aruna, GAUCH-1)
- Sole crop: Pearl millet (MBH – 1100), Bunch variety of Groundnut (TMV-2, JL-24)
- Inter crop:
 - Pearl millet + pigeonpea (2:1)
 - Maize + pigeonpea (2:1) at 50 cm spacing. Pigeonpea duration of 180-200 days

August: Very late onset of monsoon

- Sole crop:
 - Setaria (H-1, Arjuna) for grain to poultry feed and straw for fodder
 - Castor (Aruna, GAUCH-1) with increased seed rate (15 kg/ha)

Warangal

For Red soils

- **June: Normal onset of monsoon**
 - 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: Late onset of monsoon**
 - Sow castor (Aruna, GAUCH-1)
 - Sole crop: Pearl millet (MBH-100), Bunch variety of Groundnut (TMV-2, JL-24)
 - Intercrop:
 - Maize + pigeonpea (2:1) at 50 cm spacing. Pigeonpea duration of 180-200 days

- August: Very late onset of monsoon
 - Sole crop: Setaria (H-1, Arjuna) for grain to poultry feed and straw for fodder, Castor (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)

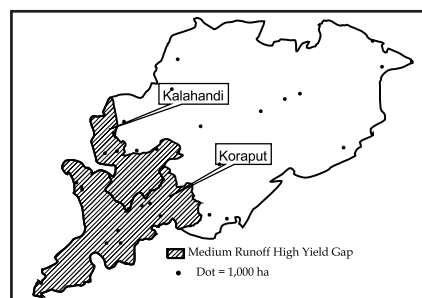
Second crop

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

Orissa

In Orissa there are two districts viz, Kalahandi and Koraput under Medium runoff and high yield gap region.

State	District	Region
Orissa	Kalahandi Koraput	Medium runoff and high yield gap



Agro-geographic Setting

Kalahandi

- Climate: Hot moist sub humid
- Physiography: Eastern ghats
- Soils: Deep loamy red and lateritic soils (Ustalfs/ Ustolls – 70%; Loamy Alfisols – 30%)
- Annual rainfall: 1511 mm
- Potential evapotranspiration: 1524 mm
- Moisture availability period: 180-210 days

Koraput

- Climate: Hot moist sub humid
- Physiography: Eastern ghats
- Soils: Deep loamy red and lateritic soils (Loamy Alfisols – 80%; Sandy Alfisols – 20%)
- Annual rainfall: 1671 mm
- Potential evapotranspiration: 1630 mm
- Moisture availability period: 180-210 days

Soil and water conservation

Kalahandi, Koraput

- Bench terracing
- Compartmental bunding
- Graded border strips
- Sowing across the slope and ridging later
- *In situ* conservation of soil moisture

Crop management

Kalahandi, Koraput

- Varieties: DCH-30, DCH-177, Aruna
- Seed rate: 15 kg/ha
- Planting Pattern: 60x30 cm
- Nutrient management: Green manuring through Subabul at the time of sowing castor to meet 75% of total N requirement.

Suitable cropping systems

Kalahandi, Koraput

- Low land rice-castor

Farm implements/ tools

Kalahandi, Koraput

- Bishu Mould board Plough
- Bullock drawn seed drill

Alternate farming systems

Kalahandi

- Fodder/ green biomass: *Dalbergia sissoo*, *Albizzia lebbeck*, *Anogeissus latifolia*, *Sesbania*, *Stylosanthes*, Marvel – 8 grass
- Fruit: Ber, custard apple, pomegranate, amla+ *kharif* spreading crops.

- Medicinal/ Aromatic Plants: *Catharanthus roseus*, *Palma rosa*, *Vetiveria zizanioides*, *Rose*, *Geranium*
- Vegetables: Onion, tomato, okra, cowpea, cluster bean, drumstick
- Non – arable wastelands:
 - Tree farming (*Sal*, *Teak*)
 - Silvi - pastoral (*Shisham/ Subabul/ Gambar* + *Stylosanthes/ Cenchrus/ mixture*)
- Arable wastelands:
 - Agri-horticulture: Fruit crops (mango/ citrus/ sapota/ pomegranate/ custard apple/ amla/ litchi/ jackfruit/ phalsa) + field crops (pulses/ oilseeds). Hybrid mango varieties viz. Pusa Amrapalli and Pusa Mallika are becoming increasingly popular in the zone.
 - Sweet potato + maize/ castor (spacing 80x25 cm)
 - Yam (100x60 cm) + maize/ castor
 - Tapioca (100x100 cm) + maize/ castor
 - Colocassia (80x25 cm) + maize/ castor
 - Alley cropping: *Subabul* (4 m interval) + groundnut/ sesame/ cowpea (grain)
 - *Leucaena* + turmeric/ginger

Koraput

- Fodder/ green biomass: *Dalbergia sissoo*, *Albizia lebbek*, *Anogeissus latifolia*, *Sesbania*, *Stylosanthes* Marvel – 8 grass
- Fruit: Ber, custard apple, pomegranate, amla + *kharif* spreading crops.
- Medicinal/ Aromatic Plants: *Catharanthus roseus*, *Palma rosa*, *Vetiveria zizanioides*, *Rose*, *Geranium*
- Vegetables: Onion, tomato, okra, cowpea, cluster bean, drumstick

Non – arable wastelands:

- Tree farming (*Sal*, *Teak*)
- Silvi-pastoral (*Shisham/Subabul/Gambar* + *Stylosanthes/Cenchrus/mixture*)

Arable wastelands:

- Agri-horticulture: Fruit crops (mango/ citrus/sapota/ pomegranate/ custard apple/ anola/ litchi /jackfruit/ phalsa) + field crops (pulses/oilseeds). Hybrid mango varieties viz. Pusa Amrapali and Pusa Mallika are becoming increasingly popular in the zone.
- Alley cropping: *Leucaena* + turmeric/ginger

Contingent planning

Kalahandi, Koraput

Normal Season:

- Rice:
 - Very early group (less than 95 days): Heera, Rudra, ZHU 11-26, Vandana
 - Early group (95 to 115 days): Pathara, Khandagiri, Udayagiri. Ghanteswari & Parijat
 - Early medium (115 to 120 days): Sarathi & Bhoi
 - Medium duration (125 to 145 days): Lalat, IR-64, Konark, Gajapati, Surendra, Jajati, Swarna, MTU-1001 and Padmini

- Late duration: Utkalaprava, Gayatri, Savitri, Prachi, Ramachani, Mahanadi and Indrabati
- Fingermillet: Dibyasinha, Nilachala, Bhairabi and Subhra
- Maize: Navjot, Vijaya, DHM-103 and Ganga-5
- Greengram: PDM-54, K- 851, Dhauli and TARM-2
- Blackgram: Pant U-30, T-9 and Sarala
- Pigeonpea: UPAS-120, R-60, T-21 and S-5
- Cowpea: SEB-2, SGL-1 and Arka Kamal
- Horsegram: Urmi and Local
- Groundnut: Smruti (OG 52-1), JL-24, ICGS-11 and AK 12-24
- Castor: Aruna, DCH-177 and DCH-30
- Rapeseed mustard: PT- 303, M-27, Parvati and Anuradha
- Sesame: Vinayak, Uma, Usha and Prachi
- Niger: Deomali (GA-10), IGP-76 and Phulbani Local
- Linseed: Kiran, Laxmi-27, Pusa-3 and Padmini
- Sunflower: Morden
- Cotton: MCU-5, NHH-44, Somanath, Savita and Bunny
- Ginger: Vardhan, China and Nadia
- Turmeric: Sudarsan, Suguna, Subarna and Rajendra Horti-5.
- Yam: Hatikhoja, Srikirti and Srirupa

Aberrant Weather:

Upland

- **Early season drought/Delay in onset of monsoon:**
 - When upland rice is completely damaged, the crop may be cut down for supplying straw to the cattle. Non-paddy crops viz. fingermillet (Subhra, Bhairabi, Dibyasingha and Godavari), greengram (K 851, PDM-11 and PDM-54), blackgram (T-9, Sarala and Pant U-30), cowpea (SEB-2, SGL-1, Arka Kamal), horsegram (Urmi), ricebean (RBL 6), sesame (Usha, Uma), castor (Aruna, DCS-9), niger (IGP-76 and Deomali) or sunflower (Morden) should be taken. Drought tolerant varieties of crop(s)/ cropping system(s) should be taken up. The crop/variety should be selected based on available effective growing season.
- **Mid-season drought:**
 - Weeding and hoeing should be done in all the crops except groundnut in flowering stage. Weeds in groundnut should be cut or uprooted not to interfere in pegging and pod formation. Hoeing creates soil mulch and decreases moisture loss from the soil. Uprooted weeds should be used as mulch between crop rows.
 - Foliar spraying of 2% urea in upland rice and fingermillet gives good results. For this, 200 g of urea is mixed with 10 l of water and sprayed on the foliage of the crop. Plant protection chemicals may be mixed with urea solution to minimize the cost of spraying. In a single spray 10 kg/ha of urea is applied through 500 l solution.
 - Excess plants in the crop row should be thinned to reduce moisture loss from the soil.
 - Use of tender twigs of *Leucaena*, *Gliricidia sepium*, *Cassia siamea* and *Mimosa invisa* and plants of sunhemp as mulch-cum-manure reduces evaporation loss from the soil.

- Spraying of planofix 10 ppm at 45 days after sowing and 20 ppm at flowering in cotton to prevent fruit drop.
- **Late season drought:**
 - Harvested rain water should be recycled as life saving irrigation.

Medium and low land:

- **Direct sown rice:**
 - Re-sowing of rice is needed if plant population is less than 50%. Line sowing of pre-germinated seeds of rice (125 days duration) should be done. Nursery for comparatively shorter duration rice varieties may be done.
 - If plant population is more than 50% and 'beushaning' is not possible, weeds are uprooted by manual means. Even distribution of plants (*Khelua*) should be taken up immediately by using local tools. Tillers with roots may be detached from hills with profuse tillering for planting in gappy areas. Urea solution (20%) may be sprayed to improve crop growth.
- **Transplanted rice:**
 - If puddling and transplanting is not possible, seedlings should not be uprooted. Weeds are removed to keep the nursery beds clean. Adequate plant protection measures are taken to protect the seedlings from disease and pest attack.
 - When rainfall occurs, puddling is done by tractor drawn power tiller or rotovator for better puddling. Close planting of 45-day old seedlings in case of medium duration varieties and 60-70 day old seedlings in late varieties should be done. There should be 60-65 hills/m². Instead of 2 to 3 seedlings, 4 to 5 seedlings/hill should be planted. Adequate fertilizer should be applied at transplanting.
 - When seedlings are insufficient, seedlings may be raised by Dapog method.

Tamil Nadu

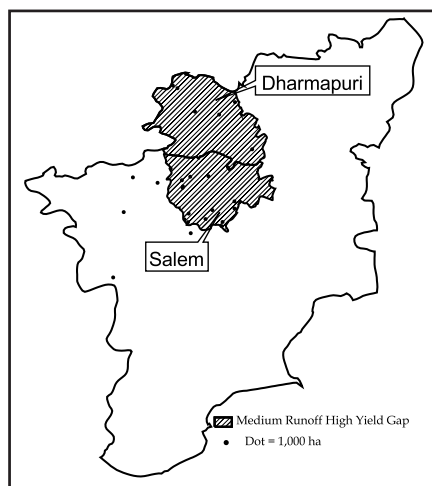
In Tami Nadu there are two districts viz, Dharmapuri and Salem under Medium runoff and high yield gap

State	District	Region
Tamil Nadu	Dharmapuri Salem	Medium runoff and high yield gap

Agro-geographic Setting

Dharmapuri

- Climate: Hot moist semi arid
- Physiography: Tamil Nadu Plains
- Soils: Deep red loamy soils (Sandy Alfisols – 100%)
- Annual rainfall: 876 mm
- Potential evapotranspiration: 1651 mm
- Moisture availability period: 120-150 days



Salem

- Climate: Hot moist semi arid
- Physiography: Tamil Nadu Plains
- Soils: Deep red loamy soils (Sandy Alfisols – 100%)
- Annual rainfall: 965 mm
- Potential evapotranspiration: 1729 mm
- Moisture availability period: 120-150 days

Soil and water conservation

Dharmapuri, Salem

- More emphasis on *in situ* water conservation and semi permanent structures
- Increasing soil infiltration capacity and reducing soil crusting problem
- Inter-plot water harvesting of 1:1 cropped to uncropped land
- Furrows at 3.6 m intervals
- On sloppy land contour cultivation along vegetative hedge of *Vetiveria* or *Leucaena* at 0.5 m Vertical interval in sorghum and cotton crops
- Supplemental irrigation by harvesting runoff water at dry spells.
- Field bunds for smaller areas may be encouraged for wider adoption.

Crop management

Dharmapuri, Salem

- Varieties: DCH-30, TMV-3, SA-2, TMV-4, DCH-32, TMVCH1, SA-2, TMV-5, TMV-6, CO-1, Jyothi (DCH-9)
- Seed rate : 15 kg/ha
- Planting pattern: 60x30 cm
- Nutrient management: Green manuring through subabul at the time of sowing castor to meet 75% of total N requirement.

Suitable cropping systems

Dharmapuri, Salem

- Castor + groundnut

Farm implements/ tools

Dharmapuri, Salem

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

Alternate farming systems

Dharmapuri, Salem

- 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)
- Silviculture: *Alianthus excelsa* + blackgram, *Alianthus excelsa* + dinanath grass
- Fodder/ green biomass: *Alianthus excelsa*, *Albizzia lebbeck*, *Leucaena leucocephala*, *Hardwickia binata*, *A.indica*
- Fruit: Mango, sapota, fig jamun, pomegranate
- Medicinal/ Aromatic Plants: *Cassia aungstifolia*, *Palma rosa*, *Vetiveria zizanioides*, jasmine, rose, geranium
- Vegetables: Okra, bittergourd, ridge gourd, chilles, brinjal, amaranthus.
- Animal Component: Sheep, goat. 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

Dharmapuri, Salem

Normal monsoon

- 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 the month of 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.

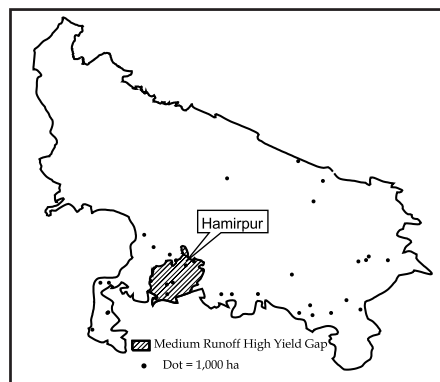
Early withdrawal of monsoon

- 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.

Uttar Pradesh

In Uttar Pradesh there is one district viz, Hamirpur under Medium runoff and high yield gap

State	District	Region
Uttar Pradesh	Hamirpur	Medium runoff and high yield gap



Agro-geographic setting

- Climate: Hot moist semi arid
- Physiography: Bundelkhand Uplands
- Soils: Deep loamy and clayey mixed red and black soils (Inceptisols -100%)
- Annual rainfall: 998 mm
- Potential evapotranspiration: 1481 mm
- Moisture availability period: 120-150 days

Soil and water conservation

- Sowing across the slope and ridging later
- Compartmental bunds for raising crops on conserved soil moisture
- More emphasis on *in situ* water conservation and semi permanent structures
- Increasing soil infiltration capacity and reducing soil crusting problem
- Supplemental irrigation by harvesting runoff water at dry spells.
- Field bunds for smaller areas may be encouraged for wider adoption.

Crop management

- Varieties: Locally available varieties
- Nutrient management: Green manuring through subabul at the time of sowing castor to meet 75% of total N requirement.

Alternate farming systems

- Fodder/ green biomass: *Leucaena*, *Melia azadirach*, *Dichrostachys cineraria*, *Albizia amara*, *Albizia lebbeck*, *Hardwickia binata*, *A.nilotica*
- Fruit: *Emblica officinalis* (amla), guava, ber, mango
- Medicinal/ Aromatic Plants: *Rauvolfia serpentina*, *Vetiveria zizanoides*, *Palma rosa*, *Safed musli*, *Aswagandha*.
- Vegetables: Bottle gourd, tomato, chillies, brinjal, cowpea, okra.
- Animal Component: Female cattle, male cattle, female buffaloes, goat, poultry

Summary

In lighter soils, the land is repeatedly ploughed in summer, as and when the rains are received, and with the onset of monsoon rains the clods are crushed by working a country plough or harrow. In clay loams, only harrowing is done with a blade-harrow two to three times to bring the soil into proper tilth. The seed is sown either in the plough furrow or with a seed-drill or by hand dibbling. The seed-rate used for sowing behind the plough is 12 kg /ha. For hand dibbling, 8 to 10 kg/ha of seed will be sufficient. Before sowing, castor seed should be treated with Thiram 3 g/kg of seed to prevent the attack of root-rot and alternaria blight. The spacing adopted generally ranges from 90-120 cm between rows and 45-60 cm between plants in the row. One or two weeding and hoeings with bullock-drawn implements are given and sometimes, the plants are earthed up. The fertilizer dose recommended for castor is 40N-40P-20K kg/ha. The entire dose of P and K and half of N is applied basally and the remaining half of N about 30 days after sowing, as and when the soil moisture is adequate.

The improved varieties cultivated at present are early maturing and take about 150 to 180 days. When one or two capsules in a bunch show signs of drying, the whole cluster is generally removed and stacked, covered and weighed in a corner of the field or in a pit. The harvesting of unripe capsules in this manner has an adverse effect on the oil content of the seed. It is preferable to collect the fruits, as and when they are ripen. When the whole crop is gathered, it is dried in the sun for a few days and threshing is done either by beating the dried capsules with a stick or by spreading them under the feet of bullocks. Winnowing is done in the usual manner.

The seedling blight and Alternaria blight cause serious losses to this crop. The sowing of the crop in low-lying and waterlogged areas should be avoided to prevent the seedling blight from appearing. For alternaria blight, seed treatment with Thiram at the rate of 3 g/kg of seed is recommended. The castor semi-looper and capsule-borer are the two most serious pests of castor. Dusting BHC 10% in early stages or spraying 0.44% Ekalux or 0.1% Carbaryl or 0.05% 1 parathion on the crop will give an effective control on these pests.

The average yield of rainfed castor varies from 200 to 500 kg /ha, that of the mixed crop from 100 to 200 kg and the irrigated crop yield from 500 to 800 kg. In eleven years (from 1964-65 to 1974-75), the average total yield of castor in India has risen to 350 kg / ha.

Promising varieties, cropping systems and other practices for other castor growing rainfed regions are given below.

Varieties

Karnataka

- DCH-32, Aruna, RC-8, Jwala, Jyothi (DCH-9)

Gujarat

- VI-9

Suitable cropping systems

Gujarat

- Castor + pigeonpea (1:1)
- Castor + cowpea (1:2)
- Castor + blackgram (1:2)
- Castor + greengram (1:2)

- Castor + groundnut (bunch) (1:3) (Saurashtra)
- Castor + sesame (1:1 or 1:2)

North Gujarat

- Castor + pearl millet (1:1 or 1:2)

Karnataka

- Castor + groundnut (1:5/ 1:7)
- Castor + horsegram (relay cropping) (1:6)

Bihar

- Castor + soybean (1:1)
- Castor + lathyrus (1:5)

2 year rotation

Karnataka

- Castor – finger millet

Some other important practices

Andhra Pradesh, Karnataka, Tamil Nadu

- Sowing time: second fortnight of June

Gujarat, Rajasthan

First fortnight of July

- For spacing 90x45 for early and medium duration variety/ hybrid.

North West Gujarat

- 90x60 cm or 120x60 cm for traditional long duration variety/ hybrids
- Square planting at 75x75 cm helps in running the blade harrow both ways and reduce the cost of intra row manual weeding. It also helps in controlling the excessive vegetative growth.
- Seed treatment with Thiram or Bavistin @ 3 g/kg seed to protect plants from seed borne diseases like Alternaria leaf blight, seedling blight and wilt.
- In rainfed areas with undulated topography, proper preparation of land, sowing the crop across the slope, 2-3 interculturalures and tying ridges along the rows after the last interculturalure helps in conservation of soil moisture apart from controlling weeds, thereby resulting in increased seed yields.
- In the event of dry spelled during 1st 50 days, apply the 1st top dressing of 20 kg N/ha at the time of initiation secondaries and when rains are received

Gujarat

- In light textured soils of Gujarat, seed treatment with *Azospirillum* or phosphorous solubilizing bacteria (PSB) @ 50 g/kg seed and application of 75-50-0 kg NPK/ha in conjunction with castor cake (1 t/ha) and FYM (5 t/ha) is advocated.

Important diseases of castor and their management

Disease	Symptoms	Stage	Cultural management	Chemical control
Seeding blight (<i>Phytophthora parasitica</i> D.)	Dull green roundish patches appear on both surfaces of cotyledons develop into alternate light and dark coloured concentric brown zones. Infection reaches growing point resulting in hanging down of leaves. Young leaves and stem is also affected.	Seedling stage	Avoid sowing in low lying areas, Provide proper field drainage.	Treat the seed with Thiram or Captan @ 3 g/kg seed. Spray Copper Oxychloride 3 g/l ⁻¹
Alternaria leaf blight (<i>Alternaria ricini</i> Y.)	Brown coloured irregular spots with concentric rings develop on leaves and merge to cause blighting and defoliation. Immature capsules turn brown to black due to deposition of spore mass on surface, pedicel collapse and capsule hangs down.	Seedling to maturity	—	Treat the seed with Thiram/ Captan 2 g/kg seed. Need based Spray of mancozeb (0.2%) 2-3 times at 15 day interval.
Wilt (<i>Fusarium oxysporum</i> s.p. <i>ricini</i> Nanda & Prasad)	Gradual yellowing, sickly appearance and marginal necrosis of leaves. Blackening of tap or secondary roots, shrinkage and cavity formation on stem, drooping of leaves resulting in irreversible wilting of affected plants	Seeding to maturity	Grow tolerant and resistant varieties like Jyoti, Jwala, GCH-4, DCH-32, GCH-5, DCH-177. Avoid water logging Intercrop castor with redgram 1:1, crop rotation with millets. Soil solarisation for 6 weeks during peak summer. Roguing and destruction of diseased plants	Treat the seed with Thiram @ 3 g/kg or Carbendazim 2 g/kg seed. Soaking of seeds in fungicidal solution (Carbendazim 1 g/l) for 12 hours and shade drying.
Root rot/die back (<i>Macrophomin a phaseolina</i> (Tassi) Goid)	Dark black lesions on the stem near ground level. Tap root shows signs of drying and root bark shreds off easily. Small brown depressed lesions seed on and around nodes. Lesions often unite and girdle the stem causing leaf drop, entire branch and top of the plant withers, drying and death starts from apex and proceed downwards.	—	Crops rotation and rouging of infected plants. Grow tolerant & resistant varieties like Jyoti, Jwala, and JHB-665. Maintain sufficient soil moisture through soil moisture conservation practices & irrigation at critical stage	Treat the seed with Thiram @ 3 g/kg or Carbendazim 2 g/kg seed.

Disease	Symptoms	Stage	Cultural management	Chemical control
Grey rot (<i>Botryotinia ricini</i> Godfrey)	Initial symptoms are small blackish spots on flower from which drops of yellow liquid may exude. Fungal threads which grow from these spots spread the infection and produce. A dense wooly growth on flowers and capsules varying in colour from pale to olive grey. Infected capsules rot, later black sclerotic are produced. Leaves and tender shoots are also infected.	Flowering and capsule development	Use of non spiny varieties (48-1), Avoid excess irrigation, Adopt wider spacing of 90x60 cm, once affected cut the diseased parts and burn. Provide additional dose of 10 kg N/ha after cessation of rains	Spray Carbendazim (0.05%) or Thiophanate methyl (0.05%) before onset of cyclonic weather based on weather forecast followed by another spray soon after disease appearance.
Cercospora leaf spot (<i>Cercospora ricinella</i> Sacc.)	Minute black or brown spots with pale green margin on both surfaces of leaves. Finally turn brown and to greyish white with a deep brown margin. Black tiny dots like structures are found in the center of the spot.	Through out the crop growth period.	—	Spray Copper Oxychloride 0.3% or Mancozeb 0.25% two to three times during cropping season in case of severe infection.
Bacterial leaf spot (<i>Xanthomonas campestris</i> pv. <i>ricini</i> Yos. & Tak)	Circular water soaked spots with pale green center and dark margin appear on the leaves. Spots become angular and turn dark brown leading to necrosis and leaf fall.	Cotyledonary stage to maturity	Field sanitation, hot water treatment of seed at 58-60°C for ten minutes.	Spray Copper Oxychloride (0.3%) or Streptocycline 1 g in 10 liters of water or Paushamycin (0.025%).
Powdery mildew (<i>Leveillula taurica</i> (Lev) Arm.)	Whitish powdery growth seen on the under surface of the leaf under favourable conditions. The surface is also covered by whitish growth of the fungus. Light green patches corresponding to diseased areas on the under surface are visible and on the upper side when the leaves held against light. The infection is wind born.	November to March	—	When the weather is comparatively dry spray twice Wettable sulphur 0.2% at 15 days interval, starting from 3 months after sowing.

Important insect pests of castor and their management

Insect	Nature of damage	Period of activity		Chemical control
Red hairy caterpillar (<i>Amsacta albistriga</i> Wlk.)	Larvae defoliate the crop. Major damage is caused by migrating caterpillars. More destruction to young crop.	Active during June to August	Setting of light traps on community basis with the first monsoon rains to attract the moths and kill them, sowing cucumber along with castor. Placing the twigs of <i>Ipomoea</i> , <i>Jatropha</i> and <i>Calotropis</i> to attract the migrating caterpillars & kill them mechanically	Spray of Monocrotophos (0.05%), Fenvalerate (0.02%), Quinalphos (0.05%), or Methyl Parathion (0.05%).
Semilooper (<i>Achoea janta</i> L.)	Damage by defoliation. Older larvae are voracious feeders and leave bare stems and veins.	July to September	Hand picking of older larvae during early stages of crop growth; avoid chemical spray when 1-2 larval parasitoids are observed per plant.	Spray Monocrotophos (0.05%) or Endosulphan (0.07%), if more than 25% defoliation is observed.
Tobacco caterpillar (<i>Spodoptera litura</i> F.)	Damage is mostly by defoliation.	Active during August to October	Collect and destroy egg masses and gregarious stages of the larvae along with damaged leaves.	Spray Chlorapyriphos (0.05%) or Monocrotophos (0.05%) if defoliation is above 25%
Hairy caterpillar (<i>Euproctis sp. Spilosoma oblique</i> Wlk.)	Damage is mostly by defoliation, often capsules get damaged.	Active during October to December	Collect & destroy egg masses and gregarious stages of the larvae along with damaged leaves.	Spray Chlorapyriphos (0.05%) or Monocrotophos (0.05%) if defolition is exceeding 25%
Capsule borer (<i>Conogethes punctiferalis</i> Guenee)	Larvae bore the capsules & characteristic webbing of capsules along with excreta is seen.	Infestation starts from flowering stage. Usually active during Nov. to March	Good agronomic management with no or less use of insecticides on the crop usually keeps the borer at low web.	Spray Monocrotophos (0.05%) or Endosulfan (0.07%) or dust the spikes with Quinalphos (1.5%) or Methyl Parathion (2%) if more than 10% capsules are damaged. If the damaged is severe spray Decamethrin (0.03%) or Acephate (0.075%)

Insect	Nature of damage	Period of activity		Chemical control
Jassid (<i>Empoasca flavescens</i> Distant)	Both nymphs and adults suck sap from plants. Hopper burn symptoms are noticed if Jassid infestation is severe.	Peak infestation is during November to January	Growing double/triple bloom genotypes like GCH-4, DCS-9, GCH-5, 48-1 etc.	Spray Monocrotophos (0.05%) or Dimethoate (0.05%). Repeat spray if required after a fortnight.
Whitefly (<i>Trialeurodes ricini</i>)	Crop gives sick appearance and sooty mould is developed when whitefly infestation is severe.	High infestation during summer on irrigated castor	—	Spray Monocrotophos (0.05%) or Dimethoate (0.05%). Repeat spray if required after a fortnight
Red spider mite (<i>Tetranychus telarius</i> L.)	Suck sap from leaves. Plants show characteristic yellowing	Serious during summer on irrigation castor (March to May)	—	Spray Dicofol (0.05%)

Important hints for getting maximum yields

Castor as a contingency crop for aberrant weather

Whenever castor plantings are delayed for one month or more beyond the recommended planting schedule in drylands, particularly in Anantapur district of Andhra Pradesh and Akola region of Maharashtra castor has been recommended as contingency crop. The following are the recommendations:

- Grow short duration varieties like Jyothi (DCS-9), Kranti (PCS-4) and GC-2 and adopt close spacing of 60x15 cm.
- Create dust mulch by blade harrowing immediately after each rain as it would prevent water loss through evaporation during the stress period.
- Apply 20 kg N/ha immediately after rains at flowering of secondary and higher order spikes.
- If irrigation facilities are available, give one or two protective irrigations between 50 and 75 days coinciding with primary/secondary/tertiary sequential order spike developmental phases. Primary and secondary order spikes together contribute 60% of total yield in dry lands.
- Whenever water levels in the reservoirs are low and the paddy plantings are delayed in the command areas or water in the well is inadequate for *rabi* rice, castor can be taken up successfully as a contingent crop in August or September or from October to January.

Exploitation of perennial castor as a bund crop

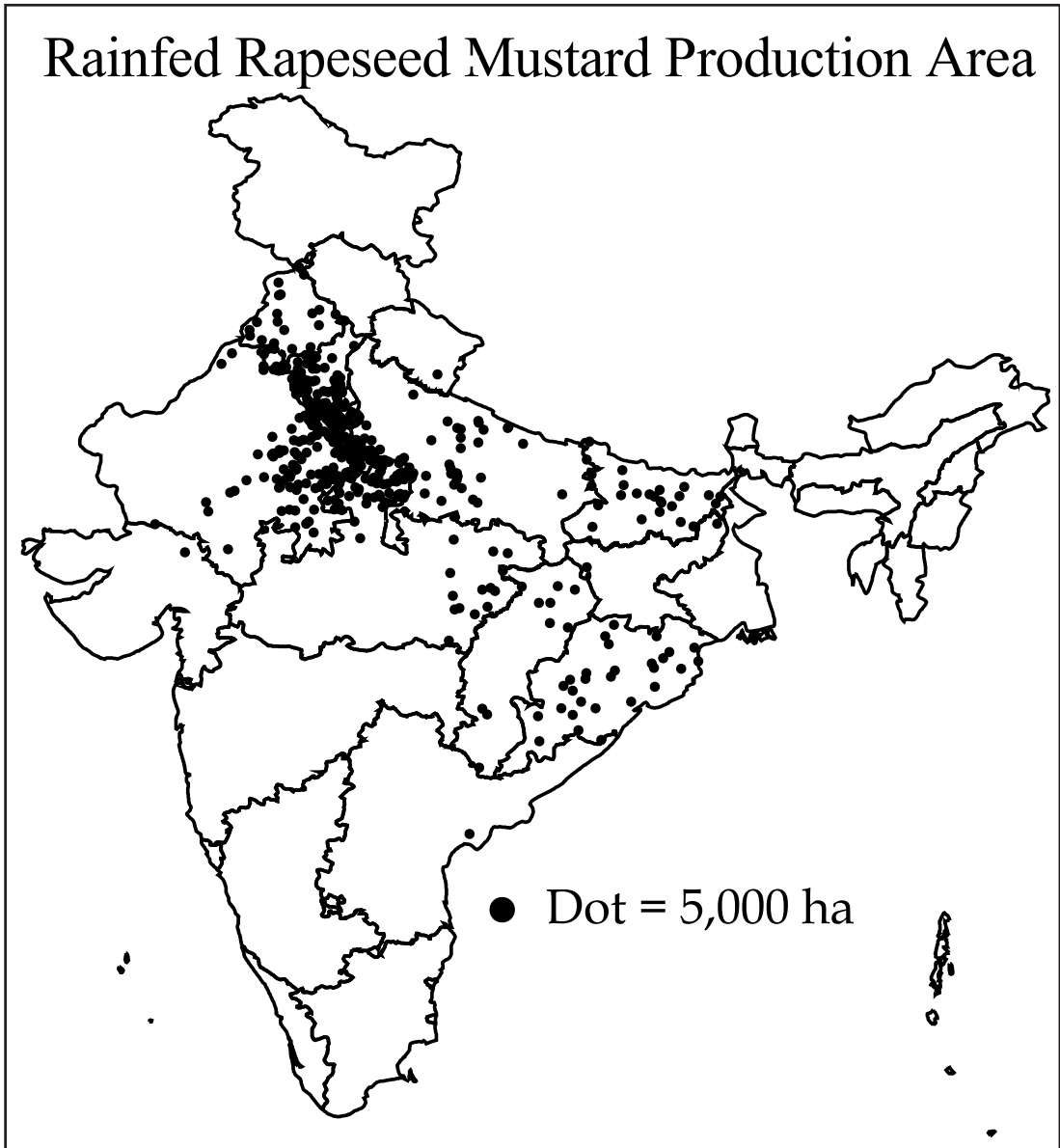
The perennial nature of castor plant makes it ideally suited for planting on field bunds, back yards, near farm houses, waste lands and on the banks of rivers, irrigation canals etc. Varieties like CO-1 in Tamil Nadu, T-1, T-4 and Kalpi-6 in U.P. and Bihar are popular. All currently recommended hybrids and varieties are also suited for such plantings. Adjust spacing on the bunds so as to accommodate at least 20-50 plants/ha. The perennial castor is grown in North Eastern India for yield and rearing eri-silk worm.

- Always use quality seeds (certified hybrid/variety seed) procured from authorized agencies.
- Avoid continuous cropping of castor year after year in the same field particularly in the wilt endemic areas and adopt at least 2 year crop rotation.

- Sow the crop with first monsoon rains by taking control measures for red hairy caterpillar.
- Recommended variety for a particular area should be chosen.
- Seed treatment with Thiram (3 g/kg of seed) should be done before sowing to prevent the attack of root rot and alternaria blight.
- Sowing should be done at the right time as recommended for different agro-climatic conditions. Sowing should be done with proper spacing as recommended for different regions.
- The recommended fertilizer schedule for the region should be adopted.
- Proper, timely and adequate plant protection measures should be adopted to save the crop from insect pests and diseases.
- Two to three intercultures should be done to provide aeration for the root system and to keep the crop free from weeds.
- The nipping of branches increases the size of the main spike and induces early maturity.
- Harvesting must be done at the right time, as too early or too late harvesting results in reduced yield, oil and shattering of seed respectively.

Prioritised cultural options for rainfed castor based production system

State	District	Prioritised Options	Average yield (kg/ha)	Expected yield (kg/ha)
Andhra Pradesh	Nalgonda, Ranga Reddy, Hyderabad, Mahaboobnagar, Guntur, Prakasam	Introduction of better management technologies including <i>in-situ</i> moisture conservation techniques, introduction of high yield cultivars	300	355 to 370
	Warangal	Introduction of better management technologies including recommended fertilizer application, introduction of high yield cultivars. Supplemental irrigation if possible	360	430 to 450
Tamilnadu	Dharmapuri, Salem	Introduction of better management technologies including recommended fertilizer application, introduction of high yield cultivars. Supplemental irrigation if possible	360	430 to 450
Orissa	Kalahandi, Koraput	Suitable water harvesting techniques for supplemental irrigation	480	560 to 600



Rapeseed Mustard Based Production System

Rapeseed mustard oilseed crops are important sources of edible oil in Indian diet. Rapeseed mustard comprising traditionally grown indigenous species, namely *Indian mustard*, *brown sarson*, *yellow sarson*, *toria* and *taramira* along with non-traditional species like *gobhi sarson*, white mustard and Ethiopian mustard. The crop is grown both in subtropical and tropical countries. In Asia, it is chiefly grown in China, India and Pakistan. It is also grown in Europe. India is the second largest rapeseed mustard growing country in the world with 6.40 million hectares (m ha) cropped area and ranks third next to Canada and china in production (4.94 mt). Its contribution to world hectarage and production is 25.6 and 14.7%, respectively. Of the 53 rapeseed mustard growing countries in the world, two countries, India and china together account for 51.4% of the hectarage and 32.6% of the production. India ranks second in area (6.40 m ha), third in production (4.94 m t) and ninth in productivity (771 kg/ha).

In India the Brassica crops occupy the second largest position after groundnut, with 3-5 million hectares, producing about 2 mt of seed annually. The chief states producing them are Uttar Pradesh, Punjab, Haryana, Assam, Bihar, Madhya Pradesh, Rajasthan, West Bengal and Orissa. These crops account for 27.5% of the total oilseeds production and 13% of the gross cropped area in the country. At the global level, it accounts for 27.5% and 20% of the total acreage and production, which was hovering around 2.68 mt with a productivity level of 650 kg/ha until 1985-86, increased to 6.10 mt in 1995-96 with productivity increasing to more than 940 kg/ha. This has been largely due to the new Integrated Oilseed Policy of the Government of India, adoption of high yielding varieties, improved agro-production and protection technologies and price incentives. Sustainable self-sufficiency has opened up new opportunities to earn valuable foreign exchange through export of oil, meal and value added products. From a net importer of vegetable oils of more than Rs 1300 crores in mid eighties, the country, with an export of 1.86 mt (seed meal and extractions), earned foreign exchange valued at Rs 261 crores during 1995-96.

Rapeseed mustard yield the most important edible oil, oil content of the seeds of different crops ranges from 30 to 46%. In the case of white mustard, the oil content ranges from 25 to 33%. The oil obtained is the main cooking medium in Northern India and cannot be replaced by any other edible oil. The seed and oil are used as a condiment in the preparation of pickles and for flavouring curries and vegetables. The oil cake is mostly used as cattle feed. The leaves of young plants are used as a green vegetable. The use of mustard oil for industrial purposes is rather limited on account of its high cost.

The rainfed rapeseed mustard occupying about 42% of the total area has not received same attention as that of irrigated crop. The crop performs well if the stored water in the soils is over 175 mm. Farmers even in arid Rajasthan grow mustard under rainfed conditions in the interdunal areas that are 'tal' lands. The option would be - growing the crop in deep soils and providing a come-up irrigation/ supplementary irrigation. More work is to be carried out to quantify the come-up irrigation needed to grow a good crop of mustard. When mustard is grown as a second crop, the stand establishment and nutrient management need special consideration.

Rapeseed mustard is grown in 4.16 mha in 265 districts out of which 1.50 mha is rainfed. About 85% of the rainfed area (1.17 mha) is in 29 districts.

Selection Criteria	No. of Districts	Area under rapeseed mustard ('000 ha)	Area under Rainfed rapeseed mustard ('000 ha)	Gross Cropped Area ('000 ha)	Yield (kg/ha)
States (16)	265	4162	1502	143785	511
Agro Eco Region **	214	3075	1385	117551	504
85% Rainfed rapeseed mustard area	29	2217	1172	16419	748

**Arid, semiarid and dry sub humid

The trends in area and yield growth rates for twenty-nine districts are given in the following table:

Area	Yield	State	District
Stagnant	Increasing	Chattisgarh Uttar Pradesh	Surguja Etawah
Stagnant	Stagnant	Madhya Pradesh Orissa	Mandla, Shahdol Koraput, Cuttack
Decreasing	Increasing	Chattisgarh	Bastar
Increasing	Increasing	Madhya Pradesh Rajasthan Uttar Pradesh	Bhind Kota Agra, Mathura
Increasing	Stagnant	Madhya Pradesh Orissa Rajasthan	Morena, Gwalior, Shivpuri Balasore, Dhenkanal Bharatpur, Alwar, Sawai Madhopur, Jaipur, Tonk, Bhundi
Decreasing	Stagnant	Orissa	Kalahandi
Stagnant	Decreasing	Orissa	Phulbani

The popular production systems are -

Agro ecoregion	Production system
Hot semi-arid Northern plains (and central Highlands)	Fallow – Rapeseed mustard Soybean – Rapeseed mustard Blackgram/ Greengram – Rapeseed mustard Pearlmillet – Rapeseed mustard
Hot sub-humid Northern plains	Maize – Rapeseed mustard
Hot sub-humid (dry) central Highlands	Pulses – Rapeseed mustard Rice – Rapeseed mustard
Hot sub-humid Eastern plateau (Chhotanagpur)	Rice – Rapeseed mustard
Moist sub-humid Eastern plains	Rice – Rapeseed mustard

Details on associated crops and livestock are presented below:

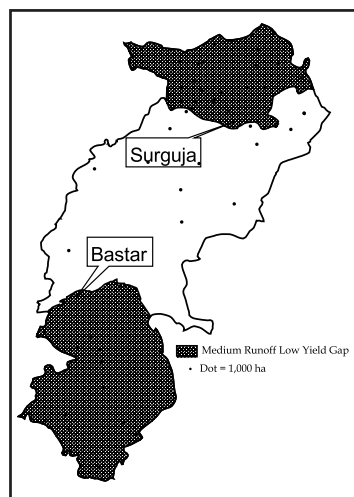
Crops	Animals	Districts
Rapeseed mustard	Female Buffalo	Gwalior, Morena, Bhind, Bhundi, Kota, Tonk, Baran
Sorghum	Sheep	
Chickpea	Goat	
Soybean		
Pearlmillet		
Vegetables		
Fruits		
Pearlmillet	Female Buffalo	Shivpuri, Alwar, Bharatpur, Jaipur, Sawai Madhopur,
Rapeseed mustard	Sheep	Mathura, Agra, Etawah, Dholpur, Dausa,
Chickpea	Goat	Kanpur (Dehat)
Sorghum		
Vegetables		
Fruits		
Rice	Female Buffalo	Bastar, Surguja, Mandla, Shahdol, Kheri, Balasore,
Vegetables	Sheep	Kalahandi, Dhenkanal, Koraput, Phulbani
Greengram	Goat	
Rapeseed mustard		
Fruits		

The recommendations on this crop based production system are given below state and district-wise in alphabetical order for the regions with low (<12%), medium (12–25%) and high (>25%) runoff /surplus index, and low (<33%), medium (33-66%), and high (>66%) yield gap from achievable yield (which is 70% of potential yield based on normal rainfall, soil water holding capacity and water requirement) of rapeseed mustard crop are presented:

Chattisgarh

In Chattisgarh there are two districts viz., Bastar and Surguja under medium runoff and low yield gap region.

State	District	Region
Chattisgarh	Bastar Surguja	Medium runoff and Low yield gap



Agro-geographic setting

Bastar

- Climate: Hot moist subhumid
- Physiography: Dandakaranya plateau
- Soils: Deep loamy red and lateritic soils (Loamy Alfisols – 100%)
- Annual rainfall: 1535 mm
- Potential evapotranspiration: 1393 mm
- Moisture availability period: 180-210 days

Surguja

- Climate: Hot moist sub humid
- Physiography: North Chattisgarh plateau
- Soils:
 - Ustalfs/ Ustisols - 100%
 - Deep loamy to clayey red and yellow soils
- Annual rainfall: 1406 mm
- Potential evapotranspiration: 1471 mm
- Moisture availability period: 150-180 days

Soil and water conservation

Bastar

- Bench terracing
- Compartmental bunding
- Sowing across the slope and ridging later

Surguja

- Graded trenches (16-33%) terrous with dry rubble gravel or enteritic pitched wall
- Gabion structures in water ways

Crop management

Bastar

- Varieties: Rapeseed: Toria – T-9
- Indian mustard: KRV-74, Narendra Rai (NDR 8501), RH-785, RH-9, RH-14, Vaibhav, Varuna (T-59)

Some other important practices

- Sowing in the last week of September to first week of October

Surguja

- Varieties: Rapeseed: Toria – T-9
- Indian mustard: KRV-74, Narendra Rai (NDR 8501), Pusa bold, Rohini, Jawahar mustard, RH-785, RH-9, RH-14, Vaibhav, Varuna (T-59), Jagannath.
- Seed rate: 4-5 kg/ha
- Planting pattern: 45x5 cm
- Nutrient management: 30-40 kg N+ 20 kg P₂O₅ + 10 kg K₂O

Some other important practices

- Sowing in first fortnight of October is ideal.
- Seed treatment with SD-36/ Thiram or Dithane M-45 2.5 g/kg of seed.
- Sow with seed drill at a depth of 4-5 cm
- Apply 20-40 kg P₂O₅ /ha through Single Super Phosphate in sulphur deficient soils
- Apply all the fertilizers in rows at 10-12 cm depth 2-3 days before sowing and cover with the soil.

Suitable cropping systems

Bastar

- Rice – rapeseed

Surguja

- Chickpea + rapeseed mustard (4:1)
- Greengram (for green manuring after first picking pods) – rapeseed mustard sequence cropping

Alternate farming systems

Surguja

- Fodder/ green biomass: Neem, subabul, *Hardwickia binata*, pongamia, *Cassia siamea*, bauhinia
- Fruit: Mango, guava, amla, phalsa, jamun and karonda
- Medicinal/ Aromatic plants: *Papaver somniferum*, *Palma rosa*, *Cymbopogon flexuosus*, *Vetiveria zyzanoides*.
- Vegetables: Tomato, chillies, brinjal, okra, bottle gourd, cowpea.
- Animal component: Female buffalo/ sheep, goat

Contingent planning

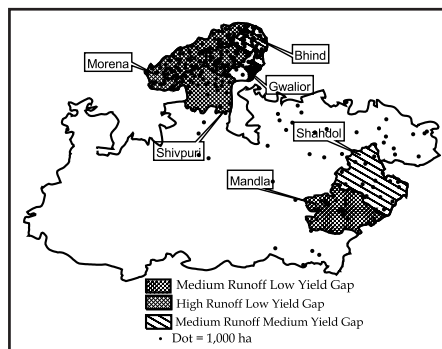
Surguja

- **June**
 - Sole crop
 - Sorghum (CSH 5, JS 1041)
 - Greengram (K 850)
 - Blackgram (JU 2, PDU 4)
 - Groundnut (Jawahar Jyoti, M 13)
 - Intercrop
 - Sorghum + pigeonpea (2:1)
 - Soybean + pigeonpea (2:1)
- **July**
 - Sole crop
 - Rice (IR 50, JR 345)
 - Kodo (JK 155, JK 76, JK 136)
 - Sorghum (CSH 5)
 - Pigeonpea (NPWR –15, JA4, Asha)
 - Groundnut (Jyoti, M 12, Exotic 1-1)
 - Intercrop
 - Sorghum + pigeonpea (2:1)
 - Soybean + pigeonpea (2:1)
- **August**
 - Castor (Aruna)
 - Pigeonpea (No.148)
- **October**
 - Wheat (JW 17, C 306)
 - Chickpea (JG 321, JG 315)
 - Linseed (JL 23, R 552)
 - Barley (Karan 4, Jyoti)
 - Lentil (JL 1, Malika)

Madhya Pradesh

In Madhya Pradesh, two districts viz., Bhind and Shahdol are under medium runoff and medium yield gap region; Gwalior, Morena and Shivpuri are under high runoff and low yield gap region and Mandla is under medium runoff and low yield gap region.

State	District	Region
Madhya Pradesh	Bhind	Medium runoff and
	Shahdol	Medium yield gap



Agro-geographic setting

Bhind

- Climate: Hot moist semi arid
- Physiography: Satpura ranges
- Soils: Deep loamy alluvium - derived soils (Vertic Inceptisols – 100%)
- Annual rainfall: 1148 mm
- Potential evapotranspiration: 1484 mm
- Moisture availability period: 120-150 days

Shahdol

- Climate: Hot dry sub humid
- Physiography: Vindhyan scraplands
- Soils: Deep loamy to clayey mixed red and black soils (Vertic Inceptisols – 60%; Ustalfs/ Ustolls – 40%)
- Annual rainfall: 1335 mm
- Potential evapotranspiration: 1342 mm
- Moisture availability period: 150-180 days

Soil and water conservation

Bhind

- Contour furrowing
- Contour trenches
- Inter plot water harvesting of 1:1 cropped to uncropped land

Shahdhol

- Broadbed furrow
- Contour farming
- Inter-plot water harvesting
- Raised bed and sunken system

Crop management

Bhind

- Varieties: Rapeseed: Toria – T-9
- Indian mustard: KRV-74, Varuna, Jawahar mustard-1, Pusa bold, Jagannath, Narendra Rai (NDR 8501), RH-785, RH-9, RH-14, Vaibhav, Varuna (T-59)
- Seed rate: 5 to 6 kg/ha
- Planting pattern: 45x15 cm
- Nutrient management: 60 kg N + 40 kg P₂O₅/ha. All to be applied as basal at 10 cm depth.
- Pest management: Aphids: Spray Endosulphan 35 E.C.

Some other important practices

- Deep tillage (20 cm) during summer and compartmental bunding just after seedling emergence reduces the runoff water and soil loss
- Greengram in *kharif* (incorporates into soil after first picking of pods) followed by rapeseed mustard in *rabi* proves much productive and remunerative sequence resulting in saving of 15 to 20 kg N / ha.
- Tillage (10-12 cm deep) by disc harrow after each effective rainfall increases *in situ* moisture for rapeseed mustard

Shahdol

- Varieties: Rapeseed: Toria – T-9
- Indian mustard: KRV-74, Pusa bold, Varuna, Jawahar mustard-1, Narendra Rai (NDR 8501), RH-785, RH-9, RH-14, Vaibhav, Varuna (T-59)
- Seed rate: 4-5 kg/ha
- Planting pattern: 45x15 cm
- Nutrient management: 30-40 kg N+ 20 kg P₂O₅ + 10 kg K₂O

Some other important practices

- Sowing in first fortnight of October is ideal.
- Seed treatment with SD-36/ Thiram or Dithane M-45 2.5 g/kg of seed.
- Sow with seed drill at a depth of 4-5 cm
- Apply 20-40 kg P₂O₅/ha through Single Super Phosphate in sulphur deficient soils
- Apply all the fertilizers in rows at 10-12 cm depth 2-3 days before sowing and cover with the soil.

Suitable cropping systems

Bhind

- Sorghum/ maize - rapeseed mustard
- Blackgram/ cowpea/ sorghum fodder – rapeseed mustard
- Chickpea + rapeseed mustard (4:1 row ratio at 30 cm apart)
- Greengram (Green manuring after first picking) – rapeseed mustard
- Pearl millet + cowpea (fodder) – chickpea + rapeseed mustard. Sow *kharif* crops early with the onset of monsoon
- Wheat + mustard (9:1)
- Lentil + mustard (5:1)
- Chickpea + mustard (4:1)

Shahdol

- Wheat + mustard (9:1)
- Lentil + mustard (5:1)
- Chickpea + mustard (4:1)

Farm implements/ tools

Bhind

- Fertilizer cum seed drill

Alternate farming systems

Bhind

- Agro - horti system: Ber + pearl millet + cowpea as fodder
- Fodder/ green biomass: Neem, Subabul, *Hardwickia brete*, Pongamia, *Cassia siamea*, Bauhinia
- Fruit: mango, guava, amla, phalsa, jamun, karonda
- Medicinal/ Aromatic plants: *Papaver somniferum*, *Palma rosa*, *Cymbopogon flexuosus*, *Vetiveria zyzanoides*.
- Vegetables: Tomato, chillies, brinjal, okra, bottle gourd, cowpea.
- Animal component: Female buffalo/ sheep, goat

Shahdhol

- Fodder/ green biomass: *Leucaena leucocephala*, *Albizia amara*, *Dichrostachys cineria*, *Melia azadirach*, *Hard wickia binata*, *A.lebbeck*
- Fruit: Mango, ber, guava, tamarind, karonda
- Medicinal/ Aromatic Plants: *Safed musli*, *Palma rosa*, *Withania somnifera*, *Papaver somniferum*, *Vetiveria zyzanoides*
- Vegetables: Brinjal, chilli, cowpea, okra, bottle gourd, round melon
- Animal component: Female and male cattle, female buffaloes, goats

Contingent planning

Bhind

Kharif

- **Under normal rainfall**
- Pearl millet (Proagro 9402), Pigeonpea (UPAS 120), Greengram (K 851), Clusterbean (RGC 197)
- **Rainfall upto end of July**
 - Cereals and pulses: Pearl millet (Proagro 9402) intercropped with pigeonpea (UPAS 120, IPCL 87), blackgram (T-9) and greengram (K 851). Pure crop of clusterbean, blackgram and greengram.
 - Oilseeds: Groundnut (Chandra) and sesame (Pratap) upto the end of third week of July
- **Rainfall upto third week of August**
 - Cereals and pulses: Clusterbean (RGC 197) and transplanting of pearl millet (MBH 163)

- **Rainfall upto end of August**
 - Clusterbean as pure crop (RGC 197)
 - Castor with a seed rate of 15 kg/ha.

Rabi

- Mustard (Pusa bold), barley (Ratna), chickpea (K 850), lentil (L 9-12), and rapeseed (Jawahar toria 1) and safflower in the order.

Shahdol

- **June**
 - Sole crop
 - Sorghum (CSH 5, JS 1041)
 - Greengram (K 850)
 - Blackgram (JU 2, PDU 4)
 - Groundnut (Jawahar Jyoti, M 13)
 - Intercrop
 - Sorghum + pigeonpea (2:1)
 - Soybean + pigeonpea (2:1)
- **July**
 - Sole crop
 - Rice (IR 50, JR 345)
 - Kodo (JK 155, JK 76, JK 136)
 - Sorghum (CSH 5)
 - Pigeonpea (NPWR -15, JA 4, Asha)
 - Groundnut (Jyoti, M 12, Exotic 1-1)
 - Intercrop
 - Sorghum + pigeonpea (2:1)
 - Soybean + pigeonpea (2:1)
- **August**
 - Castor (Aruna)
 - Pigeonpea (No.148)
- **October**
 - Wheat (JW 17, C 306)
 - Chickpea (JG 321, JG 315)
 - Linseed (JL 23, R 552)
 - Barley (Karan 4, Jyoti)
 - Lentil (JL 1, Malika)

State	District	Region
Madhya Pradesh	Gwalior Morena Shivpuri	High runoff and Low yield gap

Agro-geographic setting

Gwalior

- Climate: Hot moist semi arid
- Physiography: Madhya Bharat plateau
- Soils: Deep loamy and clayey mixed red and black soils (Vertic Inceptisols – 100%)
- Annual rainfall: 900 mm
- Potential evapotranspiration: 1504 mm
- Moisture availability period: 120-150 days

Morena

- Climate: Hot moist semi arid
- Physiography: Madhya Bharat plateau
- Soils: Deep loamy and clayey mixed red and black soils (Vertic Inceptisols – 100%)
- Annual rainfall: 927 mm
- Potential evapotranspiration: 1516 mm
- Moisture availability period: 120-150 days

Shivpuri

- Climate: Hot moist semi arid
- Physiography: Madhya Bharat plateau
- Soils: Deep loamy and clayey mixed red and black soils (Vertic Inceptisols – 100%)
- Annual rainfall: 1179 mm
- Potential evapotranspiration: 1498 mm
- Moisture availability period: 120-150 days

Soil and water conservation

Gwalior

- Contour furrowing
- Contour trenches
- Inter plot water harvesting of 1:1 cropped to uncropped land

Shivpuri, Morena

- Compartmental bunding after seedling emergence
- Contour farming

- Graded border strips
- Showing across the slope and ridging later
- To mitigate early season drought, one extra inter cultivation along with straw mulch @ 5 t/ha is effective.
- One protective irrigation is only solution to control late season drought effect during summer
- Gully plugging

Crop management

Gwalior, Morena, Shivpuri

- Varieties: Rapeseed: Toria-T-9, Jawahar toria-1
- Indian mustard: KRV-74, RH-30, Pusa bold, Jawahar mustard-1, Jagannath, Narendra Rai (NDR 8501), RH-785, RH-9, RH-14, Vaibhav, Varuna (T-59)
- Seed rate: 5 to 6 kg/ha
- Planting pattern: 45x15 cm
- Nutrient management: 60 kg N + 40 kg P₂O₅/ha. All to be applied as basal at 10 cm depth.
- Pest management: Aphids: Spray Endosulphan 35 E.C.

Some other important practices

- Deep tillage (20 cm) during summer and compartmental bunding just after seedling emergence reduces the runoff water and soil loss
- Greengram in *kharif* (incorporates into soil after first picking of pods) followed by rapeseed mustard in *rabi* proves much productive and remunerative sequence resulting in saving of 15 to 20 kg N per ha.
- Tillage (10-12 cm deep) by disc harrow after each effective rainfall increases *in situ* moisture for rapeseed mustard

Suitable cropping systems

Gwalior, Morena, Shivpuri

- Sorghum/ maize - rapeseed mustard
- Blackgram/ cowpea/ sorghum fodder - mustard
- Chickpea + rapeseed mustard (4:1 row ratio at 30 cm apart)
- Greengram (green manuring after first picking) – mustard
- Pearl millet + cowpea (fodder) – Chickpea + mustard. Sow *kharif* crops early with the onset of monsoon
- Wheat + mustard (9:1)
- Lentil + mustard (5:1)
- Chickpea + mustard (4:1)

Farm implements/ tools

Gwalior, Morena, Shivpuri

- Fertilizer cum Seed drill

Alternate farming systems

Gwalior

- Agro horticulture: Ber + greengram/ clusterbean/ cowpea for grain purpose, ber + pearl millet (fodder)
- Fodder/ green biomass: Neem, subabul, *Hardwickia binata*, *Pongamia*, *Cassia siamea*, *Bauhinia*
- Fruit: Mango, guava, amla, phalsa, jamun, karonda
- Medicinal/ Aromatic plants: *Papaver somniferum*, *Palma rosa*, *Cymbopogon flexuosus*, *Vetiveria zyzanoides*.
- Vegetables: Tomato, chillies, brinjal, okra, bottle gourd, cowpea
- Animal component: Female buffalo/ sheep, goat

Morena

- Agro – hortisystem: Mango + pea/ berseem (green fodder)/ wheat/ chickpea/ soybean
- Silvi – pastoral system: Teak + sudan grass
- Fodder/ green biomass: *Acacia indica*, *Leucaena*, *Albizzia lebbeck*, *Hardwickia binata*, *Pongamia*, *Cassia siamea*, *Bauhinia*
- Fruit: Mango, guava, amla, phalsa, jamun, karonda
- Medicinal/ Aromatic Plants: *Papaver somniferum*, *Palma rosa*, *Cymbopogon flexuosus*, *Vetiveria zyzanoides*
- Vegetables: Tomato, chillies, brinjal, okra, bottle gourd, amaranthus, cowpea
- Animal Component: Female cattle, female buffaloes, goat, poultry

Shivpuri

- Agro – hortisystem: Mango + pea/ berseem (green fodder)/ wheat/ chickpea/ soybean
- Silvi – pastoral system: Teak + sudan grass
- Fodder/green biomass: *Leucaena*, *Melia azadirach*, *Dichrostachys cineraria*, *Albizzia amara*, *Albizzia lebbeck*, *Hardwickia binata*, *Acacia nilotica*
- Ley farming – Four years continuous raising of *Stylosanthes hamata* followed by sorghum
- Fruit: *Embllica officinalis* (amla), guava, ber, mango
- Medicinal and aromatic plants: *Rauvolfia serpentina*, *Vetivera zizanoides*, *Palma rosa*, *Safed musli*, *Asgand*
- Vegetables: Bottle gourd, brinjal, tomato, chillies, brinjal, cowpea, okra
- Alternate crops in place of Greengram, blackgram/ soybean/ sunflower in place of kakun, kodan and filkar (small millets)
- Animal component: Female cattle, male cattle, female buffaloes, goat and poultry

Contingent planning

Gwalior, Morena, Shivpuri

Kharif

- **Under normal rainfall:**
- Pearl millet (ProAgro 9402), pigeonpea (UPAS 120), greengram (K 851), clusterbean (RGC 197)

- **Rainfall upto end of July**
 - Cereals and pulses: Pearl millet (Proagro 9402) intercropped with pigeonpea (UPAS 120, IPCL 87), Blackgram (T-9) and greengram (K 851). Pure crop of clusterbean, blackgram and greengram
 - Oilseeds: Groundnut (Chandra) and sesame (Pratap) upto the end of third week of July
- **Rainfall upto third week of August**
 - Cereals and pulses: Clusterbean (RGC 197) and transplanting of pearl millet (MBH 163)
- **Rainfall upto end of August**
 - Clusterbean as pure crop (RGC 197)
 - Castor with a seed rate of 15 kg/ha

Rabi

- Rapeseed mustard (Pusa Jaikisan), barley (Ratna), chickpea (K 850), lentil (L 9-12), rapeseed (TMH 1) and safflower in the order.

State	District	Region
Madhya Pradesh	Mandla	Medim runoff and Low yield gap

Agro-geographic setting

- Climate: Hot moist sub humid
- Physiography: Satpura ranges
- Soils: Shallow to deep loamy to clayey mixed red and black soils (Vertic Inceptisols – 85%; Vertisols – 15%)
- Annual rainfall: 1425 mm
- Potential evapotranspiration: 1304 mm
- Moisture availability period: 180-210 days

Soil and water conservation

- Bench terracing
- Compartmental bunding
- Graded border strips
- Sowing across the slope and ridging later

Crop management

- Varieties: Rapeseed: Toria – T-9
Indian mustard: KRV-74, Narendra Rai (NDR 8501), Pusa bold, Rohini, Jagannath, Jawahar mustard 1, RH-785, RH-9, RH-14, Vaibhav, Varuna (T-59)
- Nutrient management: 30-40 kg N + 20 kg P₂O₅ + 10 kg K₂O/ha

Some other important practices

- Sowing in first fortnight of October is ideal.
- Seed treatment with SD-36/ Thiram or Dithane M-45 2.5 g /kg of seed.
- Sow with seed drill at a depth of 4-5 cm
- Apply 20-40 kg P₂O₅ through Single Super Phosphate/ha in sulphur deficient soils
- Apply all the fertilizers in rows at 10-12 cm depth 2-3 days before sowing and cover with the soil.

Suitable cropping system

- Wheat + mustard (9:1)
- Lentil + mustard (5:1)
- Chickpea + mustard (4:1)

Alternate farming systems

- Alley cropping – Subabul (4 m interval) - + ground nut/sesame/cowpea (grain)
- Fodder/green biomass: *A. lebbbeck*, *Leucaena*, *D.sissoo*, *A.indica*, *Sesbania*, *Pongamia*
- Fruit: Ber, mango sapota, tamarind, fig
- Medicinal and aromatic plants: *Papaver somniferum*, *Rauvolfia*, *Liquorice*, safed musli, *Palma rosa*
- Vegetables: Tomato, okra, bottle gourd, ridgegourd, amaranthus, drumstick
- Animal component: Female and male cattle, female and male buffaloes

Contingent planning

Cropping systems under drylands

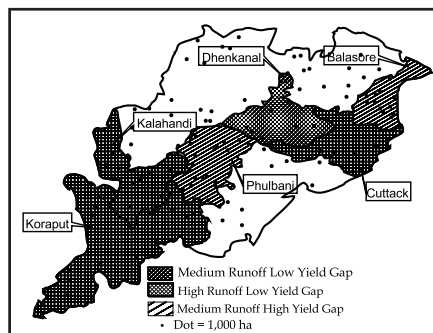
- **June**
 - Sole crop
 - Sorghum (CSH 5, JS 1041)
 - Greengram (K 850)
 - Blackgram (JU 2, PDU 4)
 - Groundnut (Jawahar Jyoti, M 13)
 - Intercrop
 - Sorghum + pigeonpea (2:1)
 - Soybean + pigeonpea (2:1)
- **July**
 - Sole crop
 - Rice (IR 50, JR 345)
 - Kodo (JK 155, JK 76, JK 136)
 - Sorghum (CSH 5)
 - Pigeonpea (NPWR –15, JA4, Asha)
 - Groundnut (Jyoti, M 12, Exotic 1-1)
 - Intercrop
 - Sorghum + pigeonpea (2:1)
 - Soybean + pigeonpea (2:1)
- **August**
 - Castor (Aruna)
 - Pigeonpea (No.148)
- **October**
 - Wheat (JW 17, C 306)

- Chickpea (JG 321, JG 315)
- Linseed (JL 23, R 552)
- Barley (Karan 4, Jyoti)
- Lentil (JL 1, Malika)

Orissa

In Orissa, Balasore and Phulbani are under medium runoff and high yield gap region; Cuttack, Kalahandi and Koraput are under high runoff and medium yield gap region; Dhenkanal is under medium runoff and low yield gap region.

State	District	Region
Orissa	Balasore Phulbani	Medium runoff and High yield gap



Agro-geographic setting

Balasore

- Climate: Hot (moist/ dry) sub humid
- Physiography: Eastern ghats/ Gangetic plains
- Soils: Medium to deep loamy red and lateritic, deep loamy to clayey coastal and Deltaic Alluvium derived soils, (Loamy Alfisols – 55%; Orthids – 45%)
- Annual rainfall: 1690 mm
- Potential evapotranspiration: 1437 mm
- Moisture availability period: 180-210 days

Phulbani

- Climate: Hot moist sub humid
- Physiography: Eastern ghats
- Soils: Deep loamy red and lateritic soils (Loamy Alfisols – 50%; Ustalfs/ Ustolls – 50%)
- Annual rainfall: 1425 mm
- Potential evapotranspiration: 1642 mm
- Moisture availability period: 180-210 days

Soil and water conservation

Balasore, Phulbani

- Bench terracing
- Compartmental bunding
- Graded border strips
- Sowing across the slope and ridging later

Crop management

Balasore, Phulbani

- Varieties: M-27 suitable for plain areas, for sequence cropping in maize-mustard and upland rice (short duration) –mustard system, Parvati, Anwadhi are the other recently released varieties.
 - Rapeseed: Toria M-27
 - Mustard: Pusa bahar, Pusa basanth, RH-785
- Seed rate: 8 kg/ha
- Planting pattern: 30x8 cm
- Nutrient management: 30 kg N + 15 kg P₂O₅ + 15 K₂O/ha. All to be applied as basal at 10 cm depth.
- Pest management: Aphids: Spray Endosulphan 35 EC

Suitable cropping systems

Balasore, Phulbani

- Rice (Lalat, Konark) – Rapeseed -Toria (PT 303, M-27, Anuradha, Parbati)
- Alternate crops
 - Mesta – AMV-1, AS-7
 - Safflower – S-2-27, A-300
 - Pearl millet – BPC-39, IP-417
 - Soybean – JS-1, Punjab-1
 - Turmeric – Sudarshan
 - Ginger – Nadia
- Chickpea + mustard (4:1)

Farm implements/ tools

Balasore, Phulbani

- Fertilizer cum Seed drill

Alternate farming systems

Balasore, Phulbani

Non – arable wastelands:

- Tree farming (Sal, Teak)
- Silvi-pastoral (*Shisham/ Subabul/ Gambar* + Stylosanthes/ Cenchrus/ mixture)
- Arable wastelands:
 - Agri - horticulture: Fruit crops (mango/citrus/sapota/pomegranate/custard apple/ anola/ litchi/ jackfruit/ phalsa) + field crops (pulses/oilseeds). Hybrid mango viz. Pusa Amrapalli and Pusa Mallika are becoming increasingly popular in the zone.
 - Sweet potato + maize/castor (spacing 80x25 cm)
 - Yam (100x60 cm) + maize/ castor
 - Tapioca (100x100 cm) + maize/ castor
 - Colocassia (80x25 cm) + maize/ castor
 - Alley cropping: Subabul (4 m interval) + groundnut/ sesame/ cowpea (grain)

- *Leucaena* + turmeric/ ginger
- Tree on crop lands: *Albizzia spp*, *Cassia siamea*, *Gravellea robusta*, *Dalbergia sissioo*
- Fruit: Mango, jackfruit, guava, Lime.
- Medicinal/aromatic plants: *Vetiveria zyzanoides*, *Cymbopogon flexuos*, *Palma rosa*, *Solanum viarum*, *Cinnemon*, *Citronella fara*.
- Vegetables: Bottle gourd, ridge gourd, watermelon, long melon, tomato, brinjal.
- Animal component: Female buffalo/ sheep, goat

Contingent planning

Balasore, Phulbani

Normal season:

- Rice:
 - Very early group (less than 95 days): Heera, Rudra, ZHU 11-26, and Vandana
 - Early group (95 to 115 days): Pathara, Khandagiri, Udayagiri, Ghanteswari and Parijat
 - Early medium (115 to 120 days): Sarathi and Bhoi
 - Medium duration (125 to 145 days): Lalat, IR-64, Konark, Gajapati, Surendra, Jajati, Swarna, MTU-1001 and Padmini
 - Late duration: Utkalaprava, Gayatri, Savitri, Rachi, Ramachani, Mahanadi and Indrabati
- Fingermillet: Dibyasinha, Nilachala, Bhairabi and Subhra
- Maize: Navjot, Vijaya, DHM-103 and Ganga-5
- Greengram: PDM-54, K- 851, Dhauri and TARM-2
- Blackgram: Pant U-30, T-9 and Sarala
- Pigeonpea: UPAS-120, R-60, T-21 and S-5
- Cowpea: SEB-2, SGL-1 and Arka Kamal
- Horsegram: Urmi and Local
- Groundnut: Smruti (OG 52-1), JL-24, ICGS-11 and AK 12-24
- Castor: Aruna, DCH-177 and DCH-30
- Toria: PT- 303, M-27, Parvati and Anuradha
- Sesame: Vinayak, Uma, Usha and Prachi
- Niger: Deomali (GA-10), IGP-76 and Phulbani Local
- Linseed: Kiran, Laxmi-27, Pusa-3 and Padmini
- Sunflower: Morden
- Cotton: MCU-5, NHH-44, Somanath, Savita and Bunny
- Ginger: Vardhan, China and Nadia
- Turmeric: Sudarsan, Suguna, Subarna and Rajendra Horti-5.
- Yam: Hatikhoja, Srikirti and Srirupa

Aberrant weather

Upland

- **Early season drought/Delay in onset of monsoon:**
 - When upland rice is completely damaged, the crop may be cut down for supplying straw to the cattle. Non-paddy crops viz. Finger millet (Subhra, Bhairabi, Dibyasingha and Godavari), greengram (K 851, PDM-11 and PDM-54), blackgram (T-9, Sarala and Pant U-30), cowpea (SEB-2, SGL-1, Arka Kamal), horsegram (Urmi), ricebean (RBL 6), sesame (Usha, Uma) and castor (Aruna, DCS-9), niger (IGP-76 and Deomali) or sunflower (Morden) should be taken. Drought tolerant varieties of crop(s)/ cropping system(s) should be taken up. The crop/ variety should be selected basing on available effective growing season.
- **Mid-season drought:**
 - Weeding and hoeing should be done in all the crops except groundnut in flowering stage. Weeds in groundnut should be cut or uprooted not to interfere in pegging and pod formation. Hoeing creates a soil mulch and decreases moisture loss from the soil. Uprooted weeds should be used as mulch between crop rows.
 - Foliar spraying of 2% urea in upland rice and finger millet gives good results. For this, 200 g of urea is mixed with 10 l of water and sprayed on the foliage of the crop. Plant protection chemicals may be mixed with urea solution to minimize the cost of spraying. In a single spray 10 kg/ha of urea is applied through 500 l solution.
 - Excess plants in the crop row should be thinned to reduce moisture loss from the soil.
 - Use of tender twigs of *Leucaena*, *Glyricidia sepium*, *Cassia siamea* and *Mimosa invisa* and plants of sunhemp as mulch cum manure reduces evaporation loss from the soil.
 - Spraying of Planofix 10 ppm at 45 days after sowing and 20 ppm at flowering in cotton to prevent fruit drop.
- **Late season drought:**
 - Harvested rainwater should be recycled as life saving irrigation.

Medium and low land:

- **Direct sown rice:**
 - Re-sowing of rice is needed if plant population is less than 50%. Line sowing of pre-germinated seeds of rice (125 days duration) should be done. Nursery for comparatively shorter duration rice varieties may be done.
 - If plant population is more than 50% and '*beushaning*' is not possible, weeds are uprooted by manual means. Even distribution of plants (*Khelua*) should be taken up immediately by using local tools. Tillers with roots may be detached from hills with profuse tillering for planting in gappy areas. Urea solution (2%) may be sprayed to improve crop growth.
- **Transplanted rice:**
 - If puddling and transplanting is not possible, seedlings should not be uprooted. Weeds are removed to keep the nursery beds clean. Adequate plant protection measures are taken to protect the seedlings from disease and pest attack.
 - When rainfall occurs, puddling is done by tractor drawn power tiller or rotovator for better puddling. Close planting of 45-day old seedlings in case of medium duration varieties and 60-70 day old seedlings in late varieties should be done. There should be 60-65 hills/m². Instead of 2 to 3 seedlings, 4 to 5 seedlings/hill should be planted. Adequate fertilizer should be applied at transplanting.
 - When seedlings are insufficient, seedlings may be raised by dapog method.

State	District	Region
Orissa	Cuttack Kalahandi Koraput	High runoff and Medium yield gap

Agro-geographic setting

Cuttack

- Climate: Hot (moist/ dry) sub humid
- Physiography: Eastern ghats
- Soils: Medium to deep loamy red and lateritic, deep loamy to clayey coastal and Deltaic Alluvium derived soils, deep loamy to clayey coastal and deltaic alluvium - derived soils (Loamy Alfisols – 60%; Orthids – 50%)
- Annual rainfall: 1559 mm
- Potential evapotranspiration: 1504 mm
- Moisture availability period: 180-210 days

Kalahandi

- Climate: Hot moist sub humid
- Physiography: Eastern ghats
- Soils: Deep loamy red and lateritic soils (Ustalfs/ Ustolls – 70%; Loamy Alfisols – 30%)
- Annual rainfall: 1511 mm
- Potential evapotranspiration: 1524 mm
- Moisture availability period: 180-210 days

Koraput

- Climate: Hot moist sub humid
- Physiography: Eastern ghats
- Soils: Deep loamy red and lateritic soils (Loamy Alfisols- 80%; Sandy Alfisols – 20%)
- Annual rainfall: 1671 mm
- Potential evapotranspiration: 1630 mm
- Moisture availability period: 180-210 days

Soil and water conservation

Cuttack, Kalahandi, Koraput

- Bench terracing
- Compartmental bunding
- Graded border strips
- Sowing across the slope and ridging later

Crop management

Cuttack, Kalahandi, Koraput

- Varieties: M-27, Parbati, Anuradha of Toria (rapeseed) suitable for plain areas, suitable for sequence cropping in maize- mustard and upland rice (short duration) - rapeseed system.
 - Rapeseed: Toria M-27
 - Mustard: Pusa bahar, Pusa basanth, RH-785, Sanjucta.
- Seed rate: 8 kg/ha
- Planting pattern: 30x8 cm
- Nutrient management: 30 kg N + 15 kg P₂O₅ + 15 kg K₂O/ha. All to be applied as basal at 10 cm depth.
- Pest management: Aphids: Spray Endosulphan 35 E.C.

Suitable cropping systems

Cuttack, Kalahandi, Koraput

- Rice (Lalat, Konark) – rapeseed toria (M-27, Anuradha, Parbati), Mustard: Pusa bold
- Alternate crops – Mesta – AMV –1, AS –7
 - Safflower – S-2-27, A-300
 - Pearl millet – BPC-39, IP-417
 - Soybean – JS – 1, Punjab –1
 - Turmeric – Sudarshan
 - Ginger – Nadia
- Chickpea + mustard (4:1)

Farm implements/ tools

Cuttack, Kalahandi, Koraput

- Fertilizer cum seed drill

Alternate farming system

Cuttack, Kalahandi, Koraput

Non – arable wastelands:

- Tree farming (Sal, Teak)
- Silvi-pastoral (*Shisham/ Subabul/ Gambar* + *Stylosanthes/ Cenchrus/* mixture)

Arable wastelands:

- Agri -horticulture: Fruit crops (mango/ citrus/ sapota/ pomegranate/ custard apple/ amla/ litchi/ jackfruit/ phalsa) + field crops (pulses/ oilseeds). Hybrid mango viz. Pusa Amrapalli and Pusa Mallika are becoming increasingly popular in the zone.
 - Sweet potato + maize/ castor (spacing 80x25 cm)
 - Yam (100x60 cm) + maize/ castor
 - Tapioca (100x100 cm) + maize/ castor
 - Colocassia (80x25 cm) + maize/ castor
 - Alley cropping: Subabul (4 m interval) + groundnut/ sesame/ cowpea (grain)

- *Leucaena* + turmeric/ ginger
- Tree on crop lands: *Albizia spp*, *Cassia siamiae*, *Gravellea robusta*, *Dalbergia sissoo*
- Fruit: Mango, jackfruit, guava, lime.
- Medicinal/aromatic plants: *Vetiveria zizanioides*, *Cymbopogon flexuosus*, *Palm rosa*, *Solanum viarum*, *Cinnemon*, *Citronella*.
- Vegetables: Bottle gourd, ridge gourd, watermelon, long melon, tomato, brinjal.
- Animal Component: Female buffalo/ sheep, goat

Contingent planning

Cuttack, Kalahandi, Koraput

Normal Season:

- Rice:
 - Very early group (less than 95 days): Heera, Rudra, ZHU 11-26 and Vandana
 - Early group (95 to 115 days): Pathara, Khandagiri, Udayagiri. Ghanteswari and Parijat
 - Early medium (115 to 120 days): Sarathi and Bhoi
 - Medium duration (125 to 145 days): Lalat, IR-64, Konark, Gajapati, Surendra, Jajati, Swarna, MTU-1001 and Padmini
 - Late duration: Utkalaprava, Gayatri, Savitri, Prachi, Ramachani , Mahanadi and Indrabati
- Fingermillet: Dibyasinha, Nilachala, Bhairabi and Subhra
- Maize: Navjot, Vijaya, DHM-103 and Ganga-5
- Greengram: PDM-54, K- 851, Dhauli and TARM-2
- Blackgram: Pant U-30, T-9 and Sarala
- Pigeonpea: UPAS-120, R-60, T-21 and S-5
- Cowpea: SEB-2, SGL-1 and Arka Kamal
- Horsegram: Urmi and Local
- Groundnut: Smruti (OG 52-1), JL-24, ICGS-11 and AK 12-24
- Castor: Aruna, DCH-177 and DCH-30
- Rapeseed Toria: PT-303, M-27, Parvati and Anuradha
- Sesame: Vinayak, Uma, Usha and Prachi
- Niger: Deomali (GA-10), IGP-76 and Phulbani Local
- Linseed: Kiran, Laxmi-27, Pusa-3 and Padmini
- Sunflower: Morden
- Cotton: MCU-5, NHH-44, Somanath, Savita and Bunny
- Ginger: Vardhan, China and Nadia
- Turmeric: Sudarsan, Suguna, Subarna and Rajendra Horti-5.
- Yam: Hatikhoja, Srikirti and Srirupa

Aberrant weather

Upland

- **Early season drought/Delay in onset of monsoon:**
 - When upland rice is completely damaged, the crop may be cut down for supplying straw to the cattle. Non-paddy crops viz. finger millet (Subhra, Bhairabi, Dibyasingha and Godavari), greengram (K 851, PDM-11 and PDM-54), blackgram (T-9, Sarala and Pant U-30), cowpea (SEB-2, SGL-1, Arka Kamal), horsegram (Urmi), ricebean (RBL 6), sesame (Usha, Uma) and castor (Aruna, DCS-9), niger (IGP-76 and Deomali) or sunflower (Morden) should be taken. Drought tolerant varieties of crop(s)/ cropping system(s) should be taken up. The crop /variety should be selected basing on available effective growing season.
- **Mid-season drought:**
 - Weeding and hoeing should be done in all the crops except groundnut in flowering stage. Weeds in groundnut should be cut or uprooted not to interfere in pegging and pod formation. Hoeing creates soil mulch and decreases moisture loss from the soil. Uprooted weeds should be used as mulch between crop rows.
 - Foliar spraying of 2% urea in upland rice and finger millet gives good results. For this, 200g of urea is mixed with 10 litre of water and sprayed on the foliage of the crop. Plant protection chemicals may be mixed with urea solution to minimize the cost of spraying. In a single spray 10 kg/ha of urea is applied through 500-litre solution.
 - Excess plants in the crop row should be thinned to reduce moisture loss from the soil.
 - Use of tender twigs of *Leucaena*, *Glyricidia sepium*, *Cassia siamea* and *Mimosa invisa* and plants of sunhemp as mulch-cum-manure reduces evaporation loss from the soil.
 - Spraying of Planofix 10 ppm at 45 days after sowing and 20 ppm at flowering in cotton to prevent fruit drop.
- **Late season drought:**
 - Harvested rainwater should be recycled as life saving irrigation.
- **Medium and low land:**
- **Direct sown rice:**
 - Re-sowing of rice is needed if plant population is less than 50%. Line sowing of pre-germinated seeds of rice (125 days duration) should be done. Nursery for comparatively shorter duration rice varieties may be done.
 - If plant population is more than 50% and 'beushaning' is not possible, weeds are uprooted by manual means. Even distribution of plants (*Khelua*) should be taken up immediately by using local tools. Tillers with roots may be detached from hills with profuse tillering for planting in gappy areas. Urea solution (2%) may be sprayed to improve crop growth.
- **Transplanted rice:**
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 - When rainfall occurs, puddling is done by tractor drawn powertiller or rotovator for better puddling. Close planting of 45-day old seedlings in case of medium duration varieties and 60-70 day old seedlings in late varieties should be done. There should be 60-65 hills/m². Instead of 2 to 3 seedlings, 4 to 5 seedlings/hill should be planted. Adequate fertilizer should be applied at transplanting.
 - When seedlings are insufficient, seedlings may be raised by dapog method.

State	District	Region
Orissa	Dhenkanal	Medium runoff and Low yield gap

Agro-geographic setting

- Climate: Hot moist sub humid
- Physiography: Eastern ghats
- Soils: Deep loamy red and lateritic soils (Loamy Alfisols – 60%; Ustalfs/ Ustolls – 40%)
- Annual rainfall: 1552 mm
- Potential evapotranspiration: 1540 mm
- Moisture availability period: 180-210 days

Soil and water conservation

- Bench terracing
- Compartmental bunding
- Graded border strips
- Sowing across the slope and ridging later

Crop management

- Varieties: M-27, Parbati, Anuradha of Toria (rapeseed) suitable for plain areas, suitable for sequence cropping in maize- rapeseed and upland rice (short duration) - rapeseed system.
 - Rapeseed: Toria M-27
 - Mustard: Pusa bahar, Pusa basanth, RH-785
- Seed rate: 8 kg/ha
- Planting pattern: 30x8 cm
- Nutrient management: 30 kg N + 15 kg P₂O₅ +15 K₂O/ha. All to be applied as basal at 10 cm depth.
- Pest management: Aphids: Spray Endosulphan 35 EC

Suitable cropping systems

- Rice (Lalat, Konark) – rapeseed mustard (PT 303, M-27, Local rai)
- Alternate crops – Mesta – AMV –1, AS –7
 - Safflower – S-2-27, A-300
 - Pearl millet – BPC-39, IP-417
 - Soybean – JS – 1, Punjab –1
 - Turmeric – Sudarshan
 - Ginger – Nadia
- Chickpea + mustard (4:1)

Farm implements/ tools

- Fertilizer cum seed drill

Alternate farming systems

Non – arable wastelands:

- Tree farming (Sal, Teak)
- Silvipastoral (Shisham/ Subabul/ Gambar + Stylosanthes/ *Cenchrus*/ mixture)

Arable wastelands:

- Agri -horticulture: Fruit crops (mango/ citrus/ sapota/ pomegranate/ custard apple/ amla/ litchi/ jackfruit/ phalsa) + field crops (pulses/ oilseeds). Hybrid mango viz. Pusa Amrapalli and Pusa Mallika are becoming increasingly popular in the zone.
- Sweet potato + maize/ castor (spacing 80x25 cm)
- Yam (100x60 cm) + maize/ castor
- Tapioca (100x100 cm) + maize/ castor
- Colocassia (80x25 cm) + maize/ castor
- Alley cropping: Subabul (4 m interval) + groundnut/ sesame/ cowpea (grain)
- *Leucaena* + turmeric/ ginger
- Tree on crop lands: *Albizzia spp*, *Cassia siamea*, *Gravellia robusta*, *Dalbergia sissoo*
- Fruit: Mango, jackfruit, guava, lime.
- Medicinal/ Aromatic plants: *Vetiveria zyzanoides*, *Cymbopogon flexosus*, *Palma rosa*, *Solanum viarum*, *cinnemon*, and *citronella fara*.
- Vegetables: Bottle gourd, ridge gourd, watermelon, long melon, tomato, brinjal.
- Animal component: Female buffalo/ sheep, goat

Contingent planning

Normal season:

- Rice:
 - Very early group (less than 95 days): Heera, Rudra, ZHU 11-26 and Vandana
 - Early group (95 to 115 days): Pathara, Khandagiri, Udayagiri. Ghanteswari and Parijat
 - Early medium (115 to 120 days): Sarathi and Bhoi
 - Medium duration (125 to 145 days): Lalat, IR-64, Konark, Gajapati, Surendra, Jajati, Swarna, MTU-1001 and Padmini
 - Late duration : Utkalaprava, Gayatri, Savitri, Prachi, Ramachani, Mahanadi and Indrabati
- Fingermillet: Dibyasinha, Nilachala, Bhairabi and Subhra
- Maize: Navjot, Vijaya, DHM-103 and Ganga-5
- Greengram: PDM-54, K- 851, Dhauri and TARM-2
- Blackgram: Pant U-30, T-9 and Sarala
- Pigeonpea: UPAS-120, R-60, T-21 and S-5
- Cowpea: SEB-2, SGL-1 and Arka Kamal
- Horsegram: Urmi and Local

- Groundnut: Smruti (OG 52-1), JL-24, ICGS-11 and AK 12-24
- Castor: Aruna, DCH-177 and DCH-30
- Rapeseed (Toria): PT- 303, M-27, Parvati and Anuradha
- Sesame: Vinayak, Uma, Usha and Prachi
- Niger: Deomali (GA-10), IGP-76 and Phulbani Local
- Linseed: Kiran, Laxmi-27, Pusa-3 and Padmini
- Sunflower: Morden
- Cotton: MCU-5, NHH-44, Somanath, Savita and Bunny
- Ginger: Vardhan, China and Nadia
- Turmeric: Sudarsan, Suguna, Subarna and Rajendra Horti-5
- Yam: Hatikhoja, Srikirti and Srirupa

Aberrant weather

Upland

- **Early season drought/ Delay in onset of monsoon:**
 - When upland rice is completely damaged, the crop may be cut down for supplying straw to the cattle. Non-paddy crops viz. finger millet (Subhra, Bhairabi, Dibyasingha and Godavari), greengram (K 851, PDM-11 and PDM-54), blackgram (T-9, Sarala and Pant U-30), cowpea (SEB-2, SGL-1, Arka Kamal), horsegram (Urmi), ricebean (RBL 6), sesame (Usha, Uma) and castor (Aruna, DCS-9), niger (IGP-76 and Deomali) or sunflower (Morden) should be taken. Drought tolerant varieties of crop(s)/ cropping system(s) should be taken up.
- **Mid-season drought:**
 - Weeding and hoeing should be done in all the crops except groundnut in flowering stage. Weeds in groundnut should be cut or uprooted not to interfere in pegging and pod formation. Hoeing creates a soil mulch and decreases moisture loss from the soil. Uprooted weeds should be used as mulch between crop rows.
 - Foliar spraying of 2% urea in upland rice and finger millet gives good results. For this, 200 g of urea is mixed with 10 l of water and sprayed on the foliage of the crop. Plant protection chemicals may be mixed with urea solution to minimize the cost of spraying. In a single spray 10 kg/ha of urea is applied through 500 l solution.
 - Excess plants in the crop row should be thinned to reduce moisture loss from the soil.
 - Use of tender twigs of *Leucaena*, *Glyricidia sepium*, *Cassia siamea* and *Mimosa invisa* and plants of sunhemp as mulch-cum-manure reduces evaporation loss from the soil.
 - Spraying of Planofix 10 ppm at 45 days after sowing and 20 ppm at flowering in cotton to prevent fruit drop.
- **Late season drought:**
 - Harvested rainwater should be recycled as life saving irrigation.
- **Medium and low land:**
- **Direct sown rice:**
 - Re-sowing of rice is needed if plant population is less than 50%. Line sowing of pre-germinated seeds of rice (125 days duration) should be done. Nursery for comparatively shorter duration rice varieties may be done.
 - If plant population is more than 50% and 'beushaning' is not possible, weeds are uprooted by manual

means. Even distribution of plants (*Khelua*) should be taken up immediately by using local tools. Tillers with roots may be detached from hills with profuse tillering for planting in gappy areas. Urea solution (2%) may be sprayed to improve crop growth.

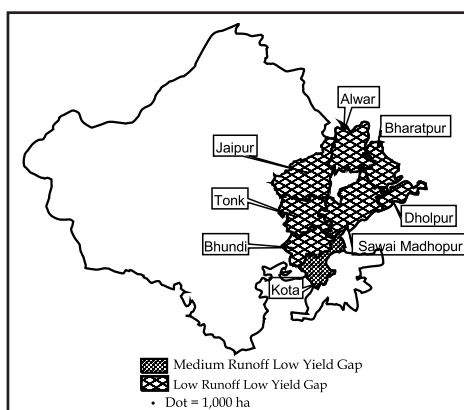
• **Transplanted rice:**

- If puddling and transplanting is not possible, seedlings should not be uprooted. Weeds are removed to keep the nursery beds clean. Adequate plant protection measures are taken to protect the seedlings from disease and pest attack.
- When rainfall occurs, puddling is done by tractor drawn power tiller or rotovator for better puddling. Close planting of 45-day old seedlings in case of medium duration varieties and 60-70 day old seedlings in late varieties should be done. There should be 60-65 hills/m². Instead of 2 to 3 seedlings, 4 to 5 seedlings/ hill should be planted. Adequate fertilizer should be applied at transplanting.
- When seedlings are insufficient, seedlings may be raised by dapog method.

Rajasthan

In Rajasthan seven districts viz., Alwar, Bharatpur, Bhundi, Dholpur, Jaipur, Sawai Madhopur and Tonk are under low runoff and low yield gap region. While Kota is under medium runoff and low yield gap region.

State	District	Region
Rajasthan	Alwar	Low runoff and Low yield gap
	Bharatpur	
	Bhundi	Medium runoff and Low yield gap
	Dholpur	
	Jaipur	
	Sawai Madhopur	
	Tonk	



Agro-geographic setting

Alwar

- Climate: Hot semi arid
- Physiography: Northern Rajasthan uplands
- Soils: Deep loamy alluvium - derived soils (Inceptisols – 100%)
- Annual rainfall: 657 mm
- Potential evapotranspiration: 1595 mm
- Moisture availability period: 90-120 days

Bharatpur

- Climate: Hot semi arid
- Physiography: Rajasthan uplands
- Soils: Deep loamy alluvium - derived soils (Inceptisols – 85%; Vertic Inceptisols – 15%)
- Annual rainfall: 664 mm

- Potential evapotranspiration: 1500 mm
- Moisture availability period: 90-120 days

Bundi

- Climate: Hot dry/ moist semi arid
- Physiography: East Rajasthan uplands
- Soils: Deep loamy grey brown and alluvium - derived soils, deep clayey black soils, shallow black soils (Vertic Inceptisols – 100%)
- Annual rainfall: 768 mm
- Potential evapotranspiration: 1554 mm
- Moisture availability period: 90-150 days

Dholpur

- Climate: Hot semi arid
- Physiography: Rajasthan uplands
- Soils: Deep loamy alluvium - derived soils (Vertic Inceptisols – 100%)
- Annual rainfall: 722 mm
- Potential evapotranspiration: 1500 mm
- Moisture availability period: 90-120 days

Jaipur

- Climate: Hot semi arid
- Physiography: Rajasthan uplands
- Soils: Deep loamy alluvium - derived soils (Inceptisols – 100%)
- Annual rainfall: 647 mm
- Potential evapotranspiration: 1745 mm
- Moisture availability period: 90-120 days

Sawai Madhopur

- Climate: Hot semi arid
- Physiography: Rajasthan uplands
- Soils: Deep loamy alluvium - derived soils (Vertisols – 85%; Inceptisols – 15%)
- Annual rainfall: 753 mm
- Potential evapotranspiration: 1569 mm
- Moisture availability period: 90-120 days

Tonk

- Climate: Hot dry semi arid
- Physiography: Rajasthan uplands
- Soils: Deep loamy grey brown and alluvium - derived soils (Inceptisols - 100%)

- Annual rainfall: 703 mm
- Potential evapotranspiration: 1597 mm
- Moisture availability period: 90-120 days

Soil and water conservation

Bharatpur

- Contour furrowing
- Contour trenches
- Inter plot water harvesting of 1:1 cropped to uncropped land

Alwar

- Compartmental bunding after seedling emergence
- Contour farming
- Graded border strips
- Sowing across the slope and ridging later
- To mitigate early season drought, one extra inter cultivation along with straw mulch @ 5 t/ha is effective.
- One protective irrigation is only solution to control late season drought effect during summer

Dholpur

- Contour furrowing
- Contour trenches
- Inter plot water harvesting of 1:1 cropped to uncropped land
- Create dust mulch (soil stirring) as and when there is dry spell.
- Deep tillage during summer increases water retention.

Bundi, Jaipur, Sawai Madhopur, Tonk

- More emphasis on *in situ* water conservation
- Increasing soil infiltration capacity and reducing soil crusting problem
- Contour furrowing
- Absorption terracing
- Contour trenches
- Inter-row water harvesting
- Inter-plot water harvesting of 1:1 cropped to un-cropped land
- Dead furrows at 3.6 m interval

Crop management

Alwar, Bharatpur

- Varieties:
 - Rapeseed: Brown Sarson: BSH-1
 - Taramira: ISTA
 - Toria: T-9
 - Indian Mustard: Aravali mustard (RL-393), RH-30, Pusa Jaikisan, Rajat, CS 52 (saline soils), Durga mani, Varuna (T-59)
 - Karan rai: Pusa Gaurav

- Seed rate: 5 to 6 kg/ha
- Planting pattern: 45x15 cm/ 30 cmx10cm
- Nutrient management:
 - 60 kg N + 40 kg P₂O₅/ha. All to be applied as basal at 10 cm depth.
 - 30 N + 15-20 P₂O₅ + 250 kg gypsum or 40 kg sulphur
- Pest management: Aphids: Spray Endosulphan 35 E.C.

Some other important practice

- Sow during 15th September to 15th October
- Apply 4-5 t FYM/ha before onset of monsoon

Bhundi, Dholpur, Jaipur, Sawai Madhopur, Tonk

- Varieties:
 - Rapeseed: Brown Sarson: BSH-1
 - Taramira: ISTA
 - Toria: T-9
 - Indian Mustard: Aravali mustard (RL-393), Pusa Jaikisan, Rajat, Vasundhara, Durga mani, Varuna (T-59)
 - Karan rai: Pusa Gaurav
- Seed rate: 5 kg/ha
- Planting pattern: 30 cmx10cm
- Integrated nutrient management: 30 kg N + 15 kg P₂O₅/ha. All to be applied as basal.
 - 60 kg N + 40 kg P₂O₅/ha. All to be applied as basal at 10 cm depth.
 - 30N + 15-20 P₂O₅ + 250 kg gypsum or 40 kg sulphur/ ha under sulphur deficient soils.

Some other important practice

- Sow during 15th September to 15th October
- Apply 4-5 t FYM/ha before onset of monsoon

Suitable cropping systems

Alwar, Bharatpur

- Sorghum/ maize- mustard
- Blackgram/ greengram/ Pearl millet - mustard
- Chickpea + rapeseed mustard (4:1row ratio at 30 cm apart)

Bhundi, Dholpur, Jaipur, Sawai Madhopur, Tonk

- Greengram (for green manuring after first picking pods) – Mustard sequence cropping
- Sorghum (fodder)/ maize (fodder) - Mustard
- Blackgram/ Greengram/ Sorghum fodder - Mustard
 - Chickpea + mustard (4:1 row ratio at 30 cm apart)

Farm implements/ tools

Alwar, Bharatpur

- Shivaji seed cum fertilizer drill

Alternate farming system

Bharatpur

- Agro horticulture: Ber + greengram/ clusterbean/ cowpea for grain purpose
- Ber + pearl millet (fodder)
- Fodder/ green biomass: Neem, Subabul, *Hardwickia binata*, Pongamia, *Cassia siamea*, Bauhinia
- Fruit: Mango, guava, amla, phalsa, jamun, karonda
- Medicinal and aromatic plants *Papaver somniferum*, *Palma rosa*, *Cymbopogon Flexous*, *Vetiveria zyzanoides*.
- Vegetables: Tomato, chillies, brinjal, okra, bottle gourd, cowpea
- Animal Component: Female buffalo/ sheep, goat

Alwar, Bhundi, Dholpur, Jaipur, Sawai Madhopur, Tonk

- Marginal lands:
 - Silviculture: *Acacia tortilis*
 - LCC III: Alley cropping (*Jatropha* spp + Greengram)
 - LCC IV: Silvipastoral system (*Prosopis cineraria* + *Cenchrus*)
- Horti – Pastoral system: Ber + *Cenchrus setigerus*
- Fodder/ green biomass: *Alianthus excelsa*, *Albizia lebbeck*, *Dalbergia sissoo*, neem, *Prosopis cineraria*
- Fruit: Ber, date palm, jamun, fig, phalsa, karonda
- Medicinal/ Aromatic plants: *Plantago ovata*, *Cassia angustifolia*, Safed musli, *Papaver somniferum*
- Vegetables: Clusterbean, cowpea, amaranthus, round melon, loup melon
- Animal component: Female buffalo/ sheep, goat

Contingent Planning

Bharatpur

Kharif

- **Under normal rainfall:**
 - Pearl millet (ProAgro 9402, HHB-67), pigeonpea (UPAS 120), greengram (K 851), clusterbean (RGC 197)
- **As the monsoon progresses**
- **Rainfall upto end of July**
 - Cereals and pulses: Pearl millet (Proagro 9402) intercropped with pigeonpea (UPAS 120, IPCL 87) blackgram (T-9) and greengram (K 851). Pure crop of clusterbean, blackgram and greengram.
 - Oilseeds: Groundnut (Chandra) and sesame (Pratap) upto the end of third week of July
- **Rainfall upto third week of August**
 - Cereals and pulses: Clusterbean (RGC 197) and transplanting of pearl millet (MBH 163)
- **Rainfall upto end of August**
 - Clusterbean as pure crop (RGC 197)
 - Castor with a seed rate of 15 kg/ha

Rabi

- Mustard (Pusa Jaikisan, RH-30, Aravalli), barley (Ratna), chickpea (K 850), lentil (L 9-12), rapeseed (TMH 1) and safflower in the order.

Alwar, Bhundi, Dholpur, Jaipur, Sawai Madhopur, Tonk

- **Good and normal rainfall**
 - Grow large areas under improved varieties of cereals, pulses and oilseeds during *kharif* on heavy soils, conserve soil moisture during *kharif* and take a early *rabi* crop of rapeseed mustard or chickpea.
- **Normal onset followed by long gaps in rainfall**
 - Drought hardy crops with deep root system and low water requirement like sorghum, castor, pigeonpea, sesame should be preferred over maize.
- **Delayed onset of monsoon**
 - Grow early maturing pulses (greengram, blackgram), oilseeds (sesame) and fodder crops (sorghum + cowpea). Intercropping of maize + blackgram/ pigeonpea, groundnut + sesame is recommended
- **Early withdrawal of monsoon**
 - Conserve the soil moisture received during last season and grow early *rabi* crops like rapeseed, mustard, chickpea, safflower etc.

State	District	Region
Rajasthan	Kota	Medium runoff and Low yield gap

Agro-geographic setting

- Climate: Hot moist semi arid
- Physiography: Western Malwa plateau
- Soils: Deep clayey black soils, shallow black soils (Vertic Inceptisols – 100%)
- Annual rainfall: 842 mm
- Potential evapotranspiration: 1523 mm
- Moisture availability period: 120-150 days

Soil and water conservation

- More emphasis on *in situ* water conservation
- Increasing soil infiltration capacity and reducing soil crusting problem
- Contour furrowing
- Absorption terracing
- Contour trenches
- Inter-row water harvesting
- Inter-plot water harvesting of 1:1 cropped to un-cropped land
- Dead furrows at 3.6 m intervals

Crop management

- Varieties:
 - Rapeseed: Brown Sarson: BSH-1
 - Taramira: ISTA
 - Toria: T-9
 - Indian Mustard: Aravali mustard (RL-393), BIO-902, Pusa jaikisan, Rajat, CS-52 (saline soils), Varuna, Durga mani, Varuna (T-59)
 - Karan rai: Pusa Gaurav
- Seed rate: 5 kg/ha
- Planting Pattern: 30 cmx10cm
- Nutrient management:
 - 30 kg N + 15 kg P₂O₅/ha. All to be applied as basal.
 - 30N + 15-20 P₂O₅ + 250 kg gypsum or 40 kg sulphur/ha in sulphur deficient soils

Some other important practices

- Sow during 15th September to 15th October
- Apply 4-5 t FYM/ha before onset of monsoon

Suitable cropping systems

- Greengram (for green manuring after first picking of pods) – mustard sequence cropping
- Sorghum/ maize-mustard
- Blackgram/ greengram/ cowpea/ sorghum fodder - mustard
- Chickpea + mustard (4:1 row ratio at 30 cm apart)

Alternate farming system

- Fodder/ green biomass: *Alianthus excelsa*, *Albizia lebbek*, *Dalbergia sissoo*, *Prosopis cineraria*, Neem
- Fruit: Ber, date palm, jamun, fig, phalsa, karonda
- 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

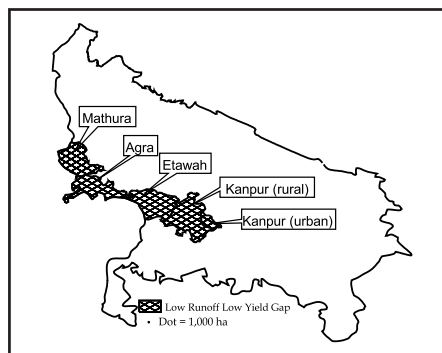
Contingent planning

- **Good and normal rainfall**
 - Grow large areas under improved varieties of cereals, pulses and oilseeds during *kharif* on heavy soils, conserve soil moisture during *kharif* and take an early *rabi* crop of rapeseed mustard or chickpea.
- **Normal onset followed by long gaps in rainfall**
 - Drought hardy crops with deep root system and low water requirement like sorghum, castor, pigeonpea, sesame should be preferred over maize.
- **Delayed onset of monsoon**
 - Grow early maturing pulses (greengram, blackgram), oilseeds (sesame) and fodder crops (sorghum + cowpea). Intercropping of maize + blackgram / pigeonpea, groundnut + sesame is recommended
- **Early withdrawal of monsoon**
 - Conserve the soil moisture received during last season and grow early *rabi* crops like rapeseed mustard, chickpea, safflower etc.

Uttar Pradesh

In Uttar Pradesh there are 5 districts viz. Agra, Etawah, Kanpur (rural), Kanpur (urban) and Mathura under low runoff and low yield gap region.

State	District	Region
Uttar Pradesh	Agra	Low runoff and
	Etawah	Low yield gap
	Kanpur (rural)	
	Kanpur (urban)	
	Mathura	



Agro-geographic setting

Agra

- Climate: Hot semi arid
- Physiography: Ganga Yamuna Doab
- Soils: Deep loamy alluvium - derived soils (Inceptisols – 100%)
- Annual rainfall: 766 mm
- Potential evapotranspiration: 1467 mm
- Moisture availability period: 90-120 days

Etawah

- Climate: Hot moist semi arid
- Physiography: Ganga – Yamuna Doab
- Soils: Deep loamy alluvium - derived soils (Inceptisols – 100%)
- Annual rainfall: 553 mm
- Potential evapotranspiration: 1464 mm
- Moisture availability period: 120-150 days

Kanpur (rural)

- Climate: Hot moist semi arid
- Physiography: Ganga – Yamuna Doab
- Soils: Deep loamy alluvium - derived soils (Inceptisols – 100%)
- Annual rainfall: 882 mm
- Potential evapotranspiration: 1661 mm
- Moisture availability period: 210

Kanpur (urban)

- Climate: Hot moist semi arid
- Physiography: Ganga – Yamuna Doab

- Soils: Deep loamy alluvium - derived soils (Inceptisols – 100%)
- Annual rainfall: 903 mm
- Potential evapotranspiration: 1576 mm
- Moisture availability period: 187

Mathura

- Climate: Hot semi arid
- Physiography: Ganga – Yamuna Doab
- Soils: Deep loamy alluvium - derived soils (Inceptisols – 100%)
- Annual rainfall: 696 mm
- Potential evapotranspiration: 1552 mm
- Moisture availability period: 90-120 days

Soil and water conservation

Agra, Etawah, Mathura

- Contour furrowing
- Contour trenches
- Inter-plot water harvesting of 1:1 cropped to uncropped land

Crop management

Agra, Etawah, Mathura

- Varieties:
 - Rapeseed: Toria: T-9
 - Indian Mustard: CS-52 (Saline and Sodic Soils), Urvashi, Maya, Kanti, Basanti, Rohini, KRV-74, Narendra Rai (NDR-8501) (Salt affected areas), RH-30, RH-9, RK-14, Shekar, Vaibhav, Varuna (T-59).
- Seed rate: 5 to 6 kg/ha
- Planting pattern: 45x15 cm
- Nutrient management: 60 kg N + 40 kg P₂O₅/ha. All to be applied as basal at 10 cm depth.
- Pest management: Aphids: Spray Endosulphan 35 EC

Some other important practices

- Deep tillage (20 cm) during summer and compartmental bunding just after seedling emergence reduces the runoff water and soil loss
- Greengram in *kharif* (incorporates into soil after first picking of pods) followed by rapeseed mustard in *rabi* proves much productive and remunerative sequence resulting in saving of 15 to 20 kg N/ha for rapeseed/ mustard
- Tillage (10-12 cm deep) by disc harrow after each effective rainfall increase in situ moisture for rapeseed mustard
- Seed treatment with Metalaxyl (Apron 35 SD @ 6 g/kg seed) is effective in controlling seedling diseases.

Kanpur (rural), Kanpur (urban)

- Varieties:
 - Rapeseed: Toria: T-9
 - Indian Mustard CS-52 (Saline and Sodic Soils), KRV-74, Rohini, Urvashi, Kanti, Basanti, Maya, Narendra Rai (NDR-8501) (Salt affected areas), RH-30, RH-9, RK-14, Shekar, Vaibhav, Varuna (T-59)

Suitable cropping systems

Agra, Etawah, Mathura

- Sorghum/ Maize- Mustard
- Blackgram/ Cowpea/ Sorghum fodder - Mustard
- Chickpea + mustard (4:1 row ratio at 30 cm apart)
- Greengram (Green manuring after first picking) – Mustard
- Pearl millet + cowpea (fodder) – chickpea + rapeseed mustard. Sow *kharif* crops early with the onset of monsoon
- Wheat + mustard (9:1)
- Lentil + mustard (5:1)
- Chickpea + mustard (4:1)

Kanpur (rural), Kanpur (urban)

- Barley + mustard
- Wheat + mustard (9:1)
- Lentil + mustard (5:1)
- Chickpea + mustard (4:1)
- Alternate crops: Greengram, blackgram, soybean, sunflower in place of small millets

Farm implements/ tools

Agra, Etawah, Mathura

- Shivaji seed cum ferti drill

Kanpur (rural), Kanpur (urban)

- Star Weeder

Alternate farming systems

Agra, Etawah, Mathura

- Agro - horti system: Ber + pearl millet + cowpea as fodder
- Agro horticulture: Ber + greengram/ clusterbean/ cowpea for grain purpose
- Ber + pearl millet (fodder)
- Fodder/ green biomass: Neem, subabul, *Hardwickia binata*, *Pongamia*, *Casuarina siamea*, *Bauhinia*
- Fruit: Mango, guava, amla, phalsa, jamun, karonda, *Papaver somniferum*, *Palma rosa*, *Cymbopogon flexuosus*, *Vetiveria zizanioides*.

- Vegetables: Tomato, chillies, brinjal, okra, bottle gourd, cowpea.
- Animal component: Female buffalo/ sheep, goat

Contingent planning

Agra, Etawah, Mathura

Kharif

- **Under normal rainfall:**
 - Pearl millet (Proagro 9402, HHB-67), pigeonpea (UPAS 120), greengram (K 851), clusterbean (RGC 197)
- **Rainfall upto end of July**
 - Cereals and Pulses: Pearl millet (Proagro 9402) intercropped with pigeonpea (UPAS 120, IPCL 87) blackgram (T-9) and greengram (K 851). Pure crop of clusterbean, blackgram and greengram.
 - Oilseeds: Groundnut (Chandra) and sesame (Pratap) upto the end of third week of July
- **Rainfall upto third week of August**
 - Cereals and pulses: Clusterbean (RGC 197) and transplanting of pearl millet (MBH 163)
- **Rainfall upto end of August**
 - Clusterbean as pure crop (RGC 197)
 - Castor with a seed rate of 15 kg/ha.

Rabi

- Mustard (Pusa Jaikisan), barley (Ratna), chickpea (K 850), lentil (L 9-12), and rapeseed (TMH 1) and safflower in the order.

Summary

Under the names rapeseed and mustard, several oilseeds belonging to the *Cruciferae* are grown in India.

- Brown mustard, commonly called rai (raya or laha)—*Brassica juncea* (L.) Czern. & Coss
- Sarson
 - Yellow sarson—*B. campestris* L. var. sarson Prain
 - Brown sarson—*B. campestris* L. var. dichotoma Watt
 - Toria (lahi or Maghi lahi)—*B. campestris* L. var. toria Duth.
 - Taramira or tara (*Eruca sativa* Mill.)

In trade, sarson, toria and taramira are known as rapeseed, and rai as mustard. Banarsi rai (*B. nigra* Koch.) which does not fall under any of the four groups is a garden crop used as spice. The cultivation of white mustard (*Brassica alba*, *Sinapis alba*) is no longer found in India. Rai and Yellow sarson are self-fertile and the rest of the cruciferous oilseeds, viz. brown sarson, toria, taramira, Banarasi rai and white mustard, are self-incompatible. The acreage under yellow sarson is scanty (mainly in Bihar, Central Uttar Pradesh, West Bengal) and constantly on the decrease. In the recent past, the acreage under brown mustard is steadily on the increase (over 90%) at the expense of other Brassica due to its higher production, greater resistant to pests and diseases and moisture stress.

Brassica juncea L. (rai) was originally introduced from China into north-eastern India. From where it has extended into Afghanistan via Punjab. Eastern Afghanistan, together with the adjoining north-western India is one of the independent centres of brown sarson (*Brassica campestris* var. brown sarson). Yellow sarson (*B. campestris* var. yellow sarson) is commonly grown in the eastern parts of India where it shows much diversity of forms. Taramira is a relatively recent introduction into India. It is believed to be a native of southern Europe and North Africa.

Rapeseed and mustard include annual herbs ranging in height from 0.45 to 1.75 m. Roots, in general, are long and tapering. Toria is more or less a surface-feeder and brown sarson has long roots, with a limited lateral spread, enabling its successful cultivation under drier conditions. Yellow sarson has both extensive and lateral spread. The height of the stem varies from 45 cm (in some varieties of toria) to 1.75 m (in yellow sarson). In toria and brown sarson, the branches arise at an angle of 30° to 40°. In yellow sarson, branches arise laterally at an angle about 10° to 20° and give the plant a narrow and pyramidal shape. The inflorescence is coriymbose raceme. In the case of sarson, the four petals are spread apart, whereas in brown sarson and toria the petals overlap or may be placed apart, depending upon the variety. The flowers bear a hypogynous syncarpous ovary. In brown sarson and toria, the ovary is bicarpellary, whereas in the case of yellow sarson, it may also be tri or tetra-carpellary. The fruit is a siliqua. The pods are two-valved, three-valved or four-valved, depending upon the number of carpels in the ovary. The flowers begin to open from 8 a.m. and continue up to 12 noon.

The rapeseed and mustard crops are of the tropical as well as of the temperate zones and require relatively cool temperatures for satisfactory growth. In India, they are grown in *rabi* season from September-October to February-March. The rapeseed and mustard crops grow well in areas having 25 to 40 cm of rainfall. Sarson and toria are preferred in low-rainfall areas, whereas raya and toria are grown in medium and high-rainfall areas respectively. The rapeseed and mustard thrive best in light to heavy loams. Raya may be grown on all types of soil, but toria does best in loam to heavy loam. Sarson is suited to light-loam soil and taramira is mostly grown on very light soils.

A fine seed-bed is required to ensure good germination. In irrigated areas, the first ploughing is done with a medium sized soil-turning plough, followed by two to four ploughings with a desi plough or a cultivator. Sohaga (Planking) is given after every ploughing. In rainfed areas, one to two ploughings with a desi plough or a cultivator, each followed by planking, may be given. Toria, in particular, requires a fairly moist seed-bed for good germination, but excessive moisture should be avoided. The rate in the case of mixed cropping depends on the proportion of the rapeseed to the main crop. When sown pure, 5 kg of seed per ha is used for all rapeseeds and mustard. When sown mixed with other crops, the time of sowing rapeseed and mustard is governed by the sowing of the main crop. September month is best for sowing toria, 25th September to 15th October for sarson, 30th September to 15th October for raya, and taramira is sown throughout October. The seed from healthy and desirable plants, grown in isolation in the case of self-sterile form, should be used. Whenever moisture in the field is inadequate, the seed is mixed with moist soil and kept overnight. For distributing evenly, the seed is usually mixed with sand before sowing.

In mixed cropping rapeseed and mustard are sown in rows 1.8 to 2.4 m apart across the main crop. The pure crop of rapeseed or mustard is sown at a depth of 4 to 5 cm in lines, 30 cm apart, with a drill, or with a (tube) attached to the plough. Thinning is done three weeks after sowing to maintain a plant to plant distance of 10 to 15 cm.

One hoeing in the case of toria in the third week after sowing and 1-2 hoeings in the case of sarson and raya are adequate. 40 -60 kg of N/ ha is optimum for all rapeseed and mustard crops in rainfed areas. For taramira, 20 kg of N/ha is sufficient. All the fertilizers should be drilled before sowing. Taramira is not irrigated.

Harvesting is done as soon as the crop begins to turn yellow. Taramira, which takes 75 to 90 days to mature, is the earliest crop to be harvested. Harvesting is done with hand-sickler. Threshing is done by beating with a wooden stick the seed bearing part of the plants, taken in convenient bundles or by trampling them under the feet. Winnowing is done with by slowly dropping the threshed produce from a basket held shoulder-high. Threshing in mustard is also done by mustard thresher. The seed after being dried in the sun is stored in gunny bags or bins.

The most serious pests of rapeseed and mustard are the mustard aphid, mustard sawfly and Painted bug. To control aphid the spraying of Methyl - O - Demeton 0.02% or 1imetboate 0.03% or Phosphomidon 0.0V/ two or three times, depending on the intensity is recommended. The mustard sawfly is controlled by dusting 10% BHC at the rate of 25 kg/ha. Endosulphan dust 4% or Methyl parathion.

Alternaria blight is the most widespread and destructive disease of rapeseed and mustard, whereas rust is serious in certain areas. Spraying with Dithane M-45 or Difolaton at the rate of 2 kg per ha is recommended for controlling these diseases. Orobanche, a parasite, has also been reported to be serious in Punjab and in certain parts of Uttar Pradesh, Rajasthan. Hand-pulling of the plants of the parasite, deep ploughing and a long rotation are recommended.

The oil of rapeseed and mustard possesses a Sizable amount of erucic acid (38 to 57%), together with linolenic acid up to 4.7 to 13.0 %. The oleic and linolenic acid, which have nutritive value, together constitute only about 27%. It is desirable to increase the quantity of oleic and linolenic acid and erucic acid. A lower proportion of erucic acid will make the oil more palatable, nutritive besides reducing metabolic disorders. The protein contained in rapeseed and mustard normally ranges between 24 and 30% on the whole-seed basis and between 35 and 40% on the meal basis. But the presence of toxic glucosinolates in the mustard cake is unsuitable as source of human protein and is at present used as a manual and as cattle feed.

Brassica campestris is synonymous *Brassica rapa* (Canola).

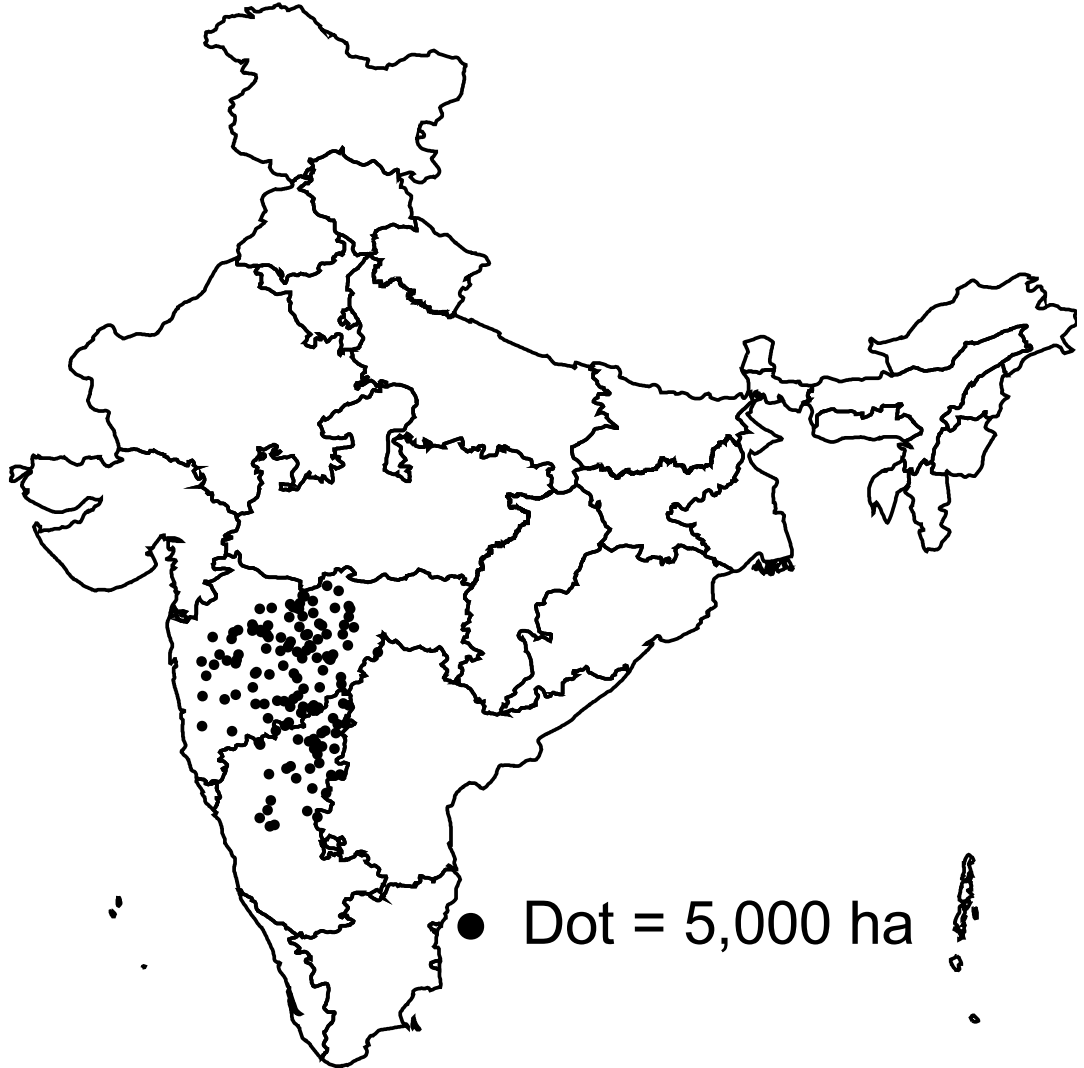
Hints for enhancing the yields of rapeseed and mustard

- Select the right crop (toria, sarson, raya and taramira) according to the soil type.
- Sow the seed of an recommended variety only.
- Prepare a fine seed-bed.
- Sow the crop during the optimum sowing period, using the recommended spacing and seed-rate.
- Apply the recommended doses of fertilizers.
- Protect the crop against insect pests, particularly aphids, by frequent spraying, using proper insecticides.
- Harvest the crop in time to avoid loss owing to shattering, especially in the case of raya

Prioritised cultural options				
State	District	Prioritised Options	Average yield (kg/ha)	Expected yield (kg/ha)
Chattisgarh	Bastar, Surguja	Suitable water harvesting techniques for further use as supplemental irrigation to reduce yield gap	610	670 to 700
Madhya Pradesh	Bhind	Suitable water management and crop management technologies to reduce yield gap, crop diversification, higher water consuming crops (vegetable) along with water harvesting techniques for enhancing crop intensity	875	1010 to 1055
	Morena	Suitable water harvesting techniques for further use as supplemental irrigation to reduce yield gap	1050	1155 to 1210
	Shahdol	Suitable water management and crop management technologies to reduce yield gap, crop diversification, higher water consuming crops (vegetable) along with water harvesting techniques for enhancing crop intensity	340	390 to 410
	Shivpuri	Suitable water management and crop management technologies to reduce yield gap, crop diversification, higher water consuming crops (vegetable) along with water harvesting techniques for enhancing crop intensity	585	645 to 675
	Mandla	Suitable water management and crop management technologies to reduce yield gap, crop diversification, higher water consuming crops (vegetable) along with water harvesting techniques for enhancing crop intensity	610	670 to 700
	Gwalior	Suitable water management and crop management technologies to reduce yield gap, crop diversification, higher water consuming crops (vegetable) along with water harvesting techniques for enhancing crop intensity	875	965 to 1010
Orissa	Cuttack, Kalahandi, Koraput	Suitable water management and crop management technologies to reduce yield gap, crop diversification, higher water consuming crops (vegetable) along with water harvesting techniques for enhancing crop intensity	465	535 to 555
	Phulbani	Suitable water management and crop management technologies to reduce yield gap, crop diversification, higher water consuming crops (vegetable) along with water harvesting techniques for enhancing crop intensity	340	390 to 410
	Dhenkanal	Permanent soil conservation works, crop diversification	610	670 to 700
	Balasore	Suitable water management and crop management technologies to reduce yield gap, crop diversification, higher water consuming crops (vegetable) along with water harvesting techniques for enhancing crop intensity	580	695 to 725

State	District	Prioritised Options	Average yield (kg/ha)	Expected yield (kg/ha)
Rajasthan	Tonk	Suitable water harvesting techniques for further use as supplemental irrigation to reduce yield gap	590	650 to 680
	Bhundi, Jaipur, Alwar, Bharatpur, Dholpur, Sawai Madhopur, Kota	New cultivars increasing production, <i>In-situ</i> conservation measures	725 885	800 to 835 970 to 1015
			880	965 to 1010
			1100	1210 to 1265
Uttar Pradesh	Agra, Etawah, Mathura	New cultivars increasing production, <i>In-situ</i> conservation measures with proper extension activities	1100	1210 to 1265
	Kanpur (rural), Kanpur (urban)	increase area Suitable water management and crop management technologies to reduce yield gap, crop diversification, higher water consuming crops (vegetable) along with water harvesting techniques for enhancing crop intensity	1050 585	1155 to 1210 645 to 675

Rainfed Safflower Production Area



SAFFLOWER BASED PRODUCTION SYSTEM

Safflower (*Carthamus tinctorius L.*) is cultivated for its seeds, which yield oil and for the extraction of a dye. The oil content varies from 24-36%. The cold-pressed oil is used for culinary purposes or for making soap. The oil obtained by dry hot distillation is black and sticky and is used only for greasing well ropes and leather goods exposed to water. In the manufacture of paints, varnishes and linoleum safflower oil is used. The crop is now cultivated, primarily for its seeds which yield oil, though at one time it used to be grown for the extraction of a dye also. The seeds are edible and are eaten after roasting. Their oil content varies from 24 to 36%, depending on the variety, soil, climate and other conditions. The cold-pressed oil is golden yellow and is used for culinary purposes, or for making soap. It can be mixed with white paint without any after-yellowing effects. The cake, particularly from decorticated seed, is used as a concentrated cattle feed, and that from undecorticated seed is sometimes used as a manure. The important safflower growing countries, besides India, are the USA, Mexico, Ethiopia, Spain, USSR and Australia. In India, it occupies 590,000 ha with a production of nearly 130,000 t. Over 98% of the area is concentrated in the states of Maharashtra (04.4%), Karnataka (26.0%) and Andhra Pradesh (8.0%).

The technology generated so far through research efforts has resulted in more than two-fold increase in the productivity of the crop in a span of two decades. The crop has proved to be more remunerative than most of the *rabi* crops in drought prone areas. High potential growth areas for this crop are non-traditional areas in Gujarat, Madhya Pradesh and West Bengal. The need for breaking the yield plateau of present varieties through exploitation of hybrid vigour is increasingly felt. The crop has high potential for export due to its high nutritional and pharmaceutical properties of oil.

Safflower is grown in 0.67 mha in 63 districts out of which 0.66 mha is rainfed. About 85% of the rainfed area (0.55 mha) is in 13 districts.

Selection Criteria	No. of Districts	Area under Safflower ('000 ha)	Area under Rainfed Safflower ('000 ha)	Gross Cropped Area ('000 ha)	Yield (kg/ha)
States (13)	63	669	660	42892	327
Agroecoregion**	51	655	646	39040	362
Cumulative 85% Rainfed Safflower Area	13	556	548	14345	420

** Arid, semi arid and dry sub humid

Growth Rates

The trends in area and yield growth rates for different districts are given in the following table:

Area	Yield	State	District
Stagnant	Increasing	Karnataka Maharashtra	Dharwad Buldhana
Stagnant	Stagnant	Karnataka Maharashtra	Gulbarga, Bijapur, Raichur Parbhani, Osmanabad, Jalna
Decreasing	Stagnant	Maharashtra	Ahmednagar, Aurangabad, Solapur, Pune, Beed

The popular production systems prevailing in various AERs is presented below:

Agro ecoregion	Production System
Hot semi-arid Northern plains	Sorghum/ maize - safflower/ mustard Blackgram/ greengram/ cowpea - safflower/ mustard Chickpea + safflower
Semi-arid Central highlands	Maize- chickpea/ safflower Soybean - safflower Maize + soybean - safflower Maize + groundnut - safflower
Hot semi-arid Deccan plateau	Pulses - safflower/ sorghum/ wheat Blackgram/ greengram/ soybean - safflower

Details on associated crops and livestock are presented below:

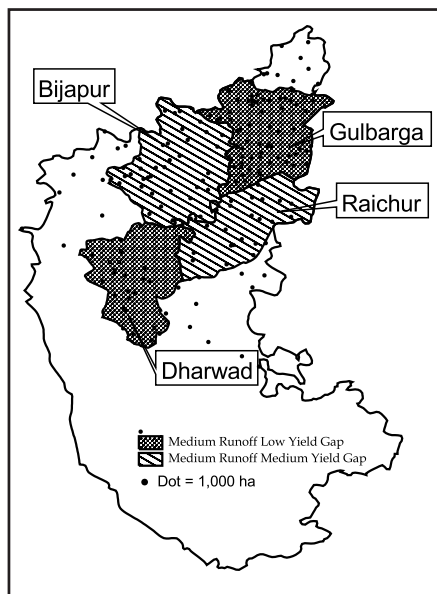
Crops	Animals	Districts
Sorghum Sunflower Groundnut Pearlmillet Cotton Safflower Fruits	Cattle Male Goats Sheep	Dharwad, Bijapur, Raichur, Gulbarga, Osmanabad
Sorghum Pearlmillet Safflower Fruits	Goats Cattle male Sheep	Pune, Aurangabad, Beed
Sorghum Pearlmillet Sugarcane Sunflower Safflower Fruits	Goats Sheep Cattle Male	Ahmednagar, Solapur
Sorghum Cotton Greengram Pearlmillet Blackgram Sunflower Sugarcane Rapeseed mustard Safflower	Goats Cattle Male Sheep	Buldhana, Parbhani, Jalna

The recommendations on this crop based production system are given below state and district-wise in alphabetical order for the regions with low (<12%), medium (12–25%) and high (>25%) runoff /surplus index, and low (<33%), medium (33-66%), and high (>66%) yield gap from achievable yield (which is 70% of potential yield based on normal rainfall, soil water holding capacity and water requirement) of safflower crop are presented:

Karnataka

In Karnataka there are two districts viz. Dharwad and Gulbarga under medium runoff and low yield gap region and two districts viz. Raichur and Bijapur under medium runoff and medium yield gap region

State	District	Region
Karnataka	Bijapur	Medium runoff and
	Raichur	Medium yield gap



Agro-geographic setting

Bijapur

- Climate: Hot arid
- Physiography: North Karnataka Plateau
- Soils: Deep loamy and clayey mixed red and black soils (Vertisols – 50%; Vertic Inceptisols – 50%)
- Annual rainfall: 573 mm
- Potential evapotranspiration: 1649 mm
- Moisture availability period: 60–120 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

Soil and water conservation

Bijapur

- Rubbles at 0.3 m vertical interval on contour key lines
- Compartmental bunding, ridges and furrows, contour cultivation
- Planting Khus grass and subabul in paired rows at vertical interval of 0.3 m
- 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
- *In situ* moisture conservation practices like compartmental bunding, ridges and furrows, contour cultivation and fall ploughing helped to conserve more moisture in deep black soils

Raichur

- Supplemental irrigation with harvested water
- Emphasis should be on farmer oriented soil conservation measures like *insitu* conservation measures
- Plant sunhemp in *rabi* areas
- Rubbles at 0.3 m vertical interval on contour key lines
- Compartmental 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

Crop management

Bijapur, Raichur

- Varieties/Hybrids: A-1, Bhima, DSH-129, MKH-11, A-300, A-1, A-2, NARI-6
- Seed rate: 8 to 10 kg/ha
- Planting pattern: 45x20 cm
- Nutrient management: 30 kg N + 15 kg P₂O₅/ha. All to be applied as basal
- Pest management
 - Aphid control:
 - Use of Bhima - moderately aphid tolerant
 - Sowing of safflower in second fortnight of September
 - Use of Neem seed extract 5 % spray
 - Spraying of 0.3 % Dimethoate on the basis of economic threshold level (ETL)

Some other important practices

- S-144 (Raichur, Bellary and Gulburga Districts)
- Medium deep to deep, well drained soils are suitable
- Seed treatment with Thiram/ Captan – 3 g and *Azotobacter* – 25 g/kg seed

Suitable cropping systems

Bijapur, Raichur

- Safflower + chickpea (2:4 or 1:3)
- Greengram - safflower
- Coriander + safflower (3:1 or 2:1)
- Wheat + safflower (3:1 or 5:1)

Farm implements/ tools

Bijapur, Raichur

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

Sequence cropping

Regions	Crop sequence
Transitional tract of Karnataka (Dharwad, Belgaum and adjoining areas)	Greengram-Safflower Soybean - safflower Groundnut-Safflower
Scanty rainfall areas of Karnataka (Medium deep black soils of Bijapur and western parts of Bellary)	Greengram-Safflower* Hybrid sorghum-Safflower* Setaria-Safflower*

* As a contingent practice depending on timely receipt and/or availability of favourable soil moisture conditions.

Alternate farming systems

Bijapur, 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: *Casuarina*, *Dalbergia sissoo*, *Hardwickia binata*, *Acacia nilotica*, *Prosopis cineraria*
- Marginal land: *Dalbergia sissoo*, neem, *Acacia nilotica*, subabul
- Alley cropping: Subabul/ casuarina + *kharif* crops
- Agro horti system: Ber (umran) + curry leaf: ber (umran) – safflower + chickpea, ber / custard apple/ pomegranate/ amla + *kharif* (spreading) crops
- Horticulture: Mango plants in levelled portion of zingg conservation terrace
- Fodder/green biomass: *Dalbergia sissoo*, *Gliricidia*, *Albizia 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: Female cattle, male cattle, female buffaloes, goat, sheep, poultry

Contingent planning

Bijapur, 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/ bengalgram/ safflower/ wheat.
- When the land is kept fallow (deep black soils) for *rabi* crops, have compartmental bunds having 1% slope, scooping where the land slope is 1 to 2%, 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 Herbaceum cottons in place of Hirsutam. 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% recommended level of fertilizer.
- Follow mixed 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%
- Use surface mulches of mixed trash or farm waste wherever possible. Where farm waste is not available, use a blade to form a thin layer of soil mulch to avoid cracks

State	District	Region
Karnataka	Dharwad Gulbarga	Medium runoff and Low yield gap

Agro-geographic setting

Dharwad

- Climate: Hot dry sub humid
- Physiography: Western Karnataka Plateau
- Soils: Shallow and medium loamy and clayey black soils, deep clayey black soils (Vertic Inceptisols – 70%; Vertisols – 30%)
- Annual rainfall: 813 mm
- Potential evapotranspiration: 1665 mm
- Moisture availability period: 150–180 days

Gulbarga

- Climate: Hot semi arid
- Physiography: North Karnataka Plateau
- Soils: Shallow and medium loamy, medium and deep clayey black soils (Vertic Inceptisols – 55%; Vertisols – 45%)
- Annual rainfall: 753 mm
- Potential evapotranspiration: 1915 mm
- Moisture availability period: 120–150 days

Soil and water conservation

Dharwad, Gulbarga

- Rubbles at 0.3 m vertical interval on contour key lines
- Compartmental 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, sissoo 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

Crop management

Dharwad, Gulbarga

- Varieties: A-1, Bhima
- Seed rate: 8 to 10 kg/ha
- Planting pattern: 45x20 cm
- Nutrient management: 30 kg N + 15 kg P₂O₅/ ha. All to be applied as basal
- Pest management
 - Aphid control:
 - Use of Bhima moderately aphid tolerant
 - Sowing of safflower in second fortnight of September.
 - Use of Neem seed extract 5% spray.
 - Spraying of 0.3% Dimethoate on the basis of economic threshold level (ETL)

Some other important practices

- Medium deep to deep, well drained soils are suitable
- Seed treatment with Thiram/ Captan – 3 g and *Azotobacter* – 25 g/kg seed
- Suitable cropping systems
- Safflower + chickpea (2:4 or 1:3)
- Greengram - safflower

Farm implements/ tools

Dharwad, Gulbarga

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

Alternate farming systems

Dharwad, Gulbarga

- 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: *Casuarina*, *Dalbergia sissoo*, *Hardwickia binata*, *Acacia nilotica*, *Prosopis cineraria*
 - Marginal land: *Dalbergia sissoo*, Neem, *Acacia nilotica*, Subabul
- Alley cropping: Subabul/ casuarina + *kharif* crops
- Agro horti system: Ber (Umran) + curry leaf, Ber (Umran) – safflower + chickpea, Ber / custard apple/ pomegranate / amla + *kharif* (spreading) crops
- Horticulture: Mango plants in leveled portion of zingg conservation terrace
- Fodder/ Green biomass: *Dalbergia sissoo*, *Gliricidia*, *Albizia lebbeck*, *Hardwickia binata*, *Cassia siamea*, *Azadirachta indica*

- Fruit: Mango, pomegranate, sapota, ber, jamun, tamarind
- Medicinal/ Aromatic Plants: *Cassia angustifolia*, *Catharanthus roseus*, *Palma rosa*, *Vetiveria zizanoides*, Rose, Geranium
- Vegetables: Onion, brinjal, chillies, cowpea, cucumber, cluster bean, drumstick
- Animal component: Female cattle, male cattle, female buffaloes, goat, sheep, poultry

Contingent planning

Dharwad, Gulbarga

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 compartmental bunds having 1% slope, scooping where the land slope is 1 to 2%, ridges and furrows or tied ridges for better soil and moisture conservation. Take up harrowings after each rain which help 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

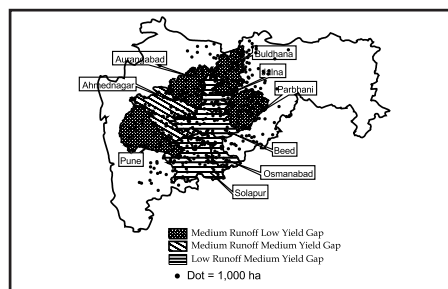
- Continue the sowing of *rabi* sorghum till October 15th with 50% recommended level of fertilizer.
- Follow mixed cropping of *rabi* sorghum + chickpea in 2:1 row proportion.
- Sow *rabi* sorghum and chickpea as mixed crops (random mixing).
- Increase the area under safflower.
- Sow chickpea and safflower 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%.
- Use surface mulches of mixed trash or farm waste wherever possible. Where farm waste is not available, use a blade to form a thin layer of soil mulch to avoid cracks.

Maharashtra

In Maharashtra there are four districts viz. Solapur, Osmanabad, Jalna and Beed under low runoff and medium yield gap region, four districts viz. Parbhani, Aurangabad, Buldhana and Pune under medium runoff and low yield gap region and one district viz. Ahmednagar under medium runoff and medium yield gap region.



State	District	Region
Maharashtra	Ahmednagar	Medium runoff and Medium yield gap

Agro-geographic setting

Ahmednagar

- Climate: Hot dry semi arid
- Physiography: Western Maharashtra Plateau
- Soils: Shallow and medium loamy black soils, deep clayey black soils, (Vertic Inceptisols – 60%; Vertisols – 40%)
- Annual Rainfall: 676 mm
- Potential Evapotranspiration: 1605 mm
- Moisture availability period: 90–120 days

Soil and water conservation

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

Crop management

- Varieties: Bhima, DSH-129, MKH-11, Shikha and JSI-73
- Seed rate: 12 kg/ha
- Planting pattern: 45x20 cm
- Nutrient management: 30 kg N + 15 kg P₂O₅/ha. All to be applied as basal
- Pest management
 - Aphid control:
 - Use of Bhima moderately aphid tolerant
 - Sowing of safflower in second fortnight of September
 - Use of Neem seed extract 5% spray
 - Spraying of 0.3% Dimethoate on the basis of economic threshold level (ETL)
 - Wilt disease:
 - Clean cultivation
 - Crop rotation
 - Use certified seed of resistant variety
 - Seed treatment with Thiram @ 2 g/kg seed
 - Leaf spots:
 - Spray with Mancozeb @ 0.25%
 - Avoid early sowing

Some other important practices

- Medium deep to deep, well drained soils are suitable
- Sowing by second fortnight of September
- Protective irrigation at 35 days after sowing (at vegetative growth and at flowering)
- Inter-cultivation – Two hoeings at 3rd and 5th week after sowing
- Seed treatment with Thiram/ Captan – 3 g and *Azotobacter* – 25 g

Suitable cropping systems

- *Rabi* Sorghum – safflower – chickpea

Intercropping System

- Chickpea + safflower (3:1 or 2:1)
- Wheat + safflower (3:1 or 2:1)
- Linseed + safflower (3:1 or 4:2)
- Coriander + safflower (3:1)

***Rabi* – *rabi* rotation**

- *Rabi* sorghum - safflower
- Safflower - chickpea
- Blackgram or greengram or cowpea for fodder followed by *rabi* sorghum, safflower, sunflower
- Sorghum for fodder followed by chickpea or safflower

Two year rotations

- Safflower or chickpea - *rabi* sorghum
- *Rabi* sorghum or chickpea - safflower

Some other important practices

Sequence cropping

- Greengram - safflower
- Blackgram - safflower
- Hybrid sorghum - safflower*
- Groundnut - safflower*
- Sesame - safflower
- Sunflower - safflower

* As a contingent practice depending on timely receipt and/or availability of favourable soil moisture conditions.

Seeding time

The optimum time of seeding stipulated for different safflower growing areas in Maharashtra advantage of first soaking rains received in September/October is as follows:

Region	Recommended seeding time
Maharashtra	
Drought prone areas of Western Maharashtra and adjoining areas of Maharashtra	Second fortnight of September
Assured rainfall areas of Western Maharashtra and Marathwada	Last week of September to mid October
Vidarbha Rainfed	Last week of September to first week of October

Farm implements/ tools

- 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 former: Bund formers were tested and found suitable for compartmental bunding. Rs.1050/-
- Baliram plough: Identified for moisture conservation practices like ridges and furrows and compartmental 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/-

Alternate farming systems

- Agri-Horti 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: *Alanthus excelsa*, *Albizia lebbbeck*, *Dalbergia sissoo*, Neem, *Prosopis cineraria*
- Fruit: Ber, date palm, jamun, fig, phalsa, karonda
- Medicinal/ aromatic plants: *Plantago ovata*, *Cassia angustifolia*, safed musli, *Papaver somniferum*
- Vegetables: Clusterbean, cowpea, amaranthus, round melon
- Animal component: Female buffalo/ sheep, goat

Contingent planning

- 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)
 - Clusterbean + pigeonpea (2:1)
 - Clusterbean + 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

State	District	Region
Maharashtra	Aurangabad Buldhana Parbhani Pune	Medium runoff and Low yield gap

Agro-geographic setting

Aurangabad

- Climate: Hot semi arid
- Physiography: Central Maharashtra Plateau
- Soils: Shallow and medium loamy, 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, 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

Parbhani

- Climate: Hot semi arid
- Physiography: Central Maharashtra Plateau
- Soils: Shallow and medium loamy, medium and deep clayey black soils (Vertic Inceptisols – 75%; Vertisols – 25%)
- Annual rainfall: 1425 mm
- Potential evapotranspiration: 1642 mm
- Moisture availability period: 120 – 150 days

Pune

- Climate: Hot dry sub humid
- Physiography: North Sahyadris
- Soils: Shallow and medium loamy, medium and deep clayey black soils, medium to deep loamy to clayey mixed red and black soils (Vertic Inceptisols – 65%; Vertisols – 35%)
- Annual rainfall: 715 mm
- Potential evapotranspiration: 1476 mm
- Moisture availability period: 90–240 days

Soil and water conservation

Buldhana

- 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 sloppy land contour cultivation along vegetative hedge of vetiver or *Leucaena* at 0.5 m vertical interval
- Broad bed furrows
- Compartmental bunding
- Sowing across the slope

Parbhani, Aurangabad

- Compartmental 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* lopping mulch at 3.5 t/ha

Pune

- Conservation furrows
- Compartmental bunding
- Broad bed furrows
- Gabion structures in waterways
- More emphasis could be given on permanent structures in Kolhapur
- Semi permanent and *insitu* conservation measures may be encouraged in Pune district

Crop management

Aurangabad, Buldhana, Parbhani

- Varieties: Bhima, N-7
- Seed rate: 12 kg/ha
- Planting pattern: 45x20 cm
- Nutrient management: 30 kg N + 15 kg P₂O₅/ha. All to be applied as basal
- Pest management
 - Aphid control:
 - Use of Bhima moderately aphid tolerant
 - Sowing of safflower in second fortnight of September
 - Use of Neem seed extract 5 % spray
 - Spraying of 0.3% Dimethoate on the basis of economic threshold level (ETL)

Pune

- Varieties: Bhima, DSH-129, MKH-11, Shikha and JSI-73
- Seed rate: 12 kg/ha
- Planting pattern: 45x20 cm
- Nutrient management: 30 kg N + 15 kg P₂O₅/ha. All to be applied as basal
- Pest management
 - Aphid control:
 - Use of Bhima moderately aphid tolerant
 - Sowing of safflower in second fortnight of September
 - Use of Neem seed extract 5 % spray
 - Spraying of 0.3% Dimethoate on the basis of economic threshold level (ETL)
 - Wilt disease:
 - Clean cultivation
 - Crop rotation
 - Use certified seed of resistant variety
 - Seed treatment with Thiram @ 2 g/kg seed
 - Leaf spots:
 - Spray with Mancozeb @ 0.25%
 - Avoid early sowing

Some other important practices

- Medium deep to deep, well drained soils are suitable
- Sowing by second fortnight of September
- Protective irrigation at 35 days after sowing (at vegetative growth and at flowering)
- Inter-cultivation – Two hoeing at 3rd and 5th week after sowing
- Seed treatment with Thiram/ Captan – 3 g and *Azotobacter* – 25 g

Suitable cropping systems

Aurangabad, Buldhana, Parbhani

- Greengram – safflower

Intercropping

- Chickpea + safflower (3:1 or 2:1)
- Wheat + safflower (3:1 or 2:1)
- Linseed + safflower (3:1 or 4:2)
- Coriander + safflower (3:1)

Pune

- *Rabi* Sorghum – safflower

Intercropping

- Chickpea + safflower (3:1 or 2:1)
- Wheat + safflower (3:1 or 2:1)
- Linseed + safflower (3:1 or 4:2)
- Coriander + safflower (3:1)

Rabi-rabi rotation

- *Rabi* sorghum - safflower
- Safflower - chickpea
- Blackgram or greengram or cowpea for fodder followed by *rabi* sorghum
- Safflower, sunflower
- Sorghum for fodder followed by chickpea or safflower

Two year rotations:

- Safflower or chickpea - *rabi* sorghum
- *Rabi* sorghum or chickpea - safflower

Some other important practices

Sequence cropping

- Greengram - safflower
- Blackgram - safflower
- Hybrid sorghum - safflower*
- Groundnut - safflower*
- Sesame - safflower
- Sunflower - safflower

* As a contingent practice depending on timely receipt and/or availability of favourable soil moisture conditions.

Seeding time

The optimum time of seeding stipulated for different safflower growing areas in Maharashtra advantage of first soaking rains received in September/October is as follows:

Region	Recommended seeding time
Maharashtra	
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Assured rainfall areas of Western Maharashtra and Marathwada	Last week of September to mid October
Vidarbha Rainfed	Last week of September to first week of October

Farm implements/ tools

Aurangabad, Buldhana, Parbhani

- Bullock drawn two-row seed cum fertilizer drill
- Bullock drawn Shivaji multipurpose farming machine

Pune

- Tractor multi crop 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/-
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- 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 former: Bund formers were tested and found suitable for compartmental bunding. Rs.1050/-
- Baliram plough: Identified for moisture conservation practices like ridges and furrows and compartmental 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/-

Alternate farming systems

Aurangabad, Buldhana

- Fodder/ green biomass: *Stylosanthes* sole and stylo-marvel pastural system recorded higher green fodder yield than sole or combination of grasses. *Leucaena leucocephala*, *Albizia lebbeck*, *Dalbergia sissoo*, *Acacia 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/ Aromatic Plants: *Solanum viarum*, *Catharanthus roseus*, *Palma rosa*, *Vetiveria zizanoides*, *Ocimum viride*
- Vegetables: Onion, chilli, brinjal, okra, amaranthus, bottle gourd
- Animal Component: Female cattle, male cattle, female buffaloes, goat, poultry

Pune, 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: *Allyanthus excelsa*, *Albizia lebbeck*, *Dalbergia sissoo*, Neem, *Prosopis cineraria*
- Fruit: Ber, date palm, jamun, fig, phalsa, karonda
- Medicinal/ aromatic plants: *Plantago ovata*, *Cassia angustifolia*, Safed musli, *Papaver somniferum*
- Vegetables: Clusterbean, cowpea, amaranthus, round melon
- Animal Component: Female buffalo/ sheep, goat

Alternate land use system

Pune

- Lands < 22.5 cm depth of soil should be cultivated with agroforestry and dryland horticulture including ber, custard apple, amla, wood apple, camphol etc.
- Silvicultural system of Subabul + Marvel-8 with cutting of the alternate trees at 7th year onwards for fuel is also recommended.

Contingent planning

Buldhana

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 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

Aurangabad, Pune, 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)
 - Clusterbean + pigeonpea (2:1)
 - Clusterbean + 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.

State	District	Region
Maharashtra	Beed Jalna Osmanabad Solapur	Low runoff and Medium yield gap

Agro-geographic setting

Beed

- Climate: Hot dry semi arid
- Physiography: Western Maharashtra plateau
- Soils: Shallow and medium loamy black soils, deep clayey black soils (Vertic Inceptisols – 100%)
- Annual rainfall: 685 mm
- Potential evapotranspiration: 1606 mm
- Moisture availability period: 90–120 days

Jalna

- Climate: Hot semi arid
- Physiography: Central Maharashtra Plateau
- Soils: Shallow and Medium loamy, 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

Osmanabad

- Climate: Hot moist semi arid
- Physiography: South Western Maharashtra Plateau
- Soils: Shallow and Medium loamy, medium and deep clayey black soils (Vertic Inceptisols – 100%)
- Annual rainfall: 809 mm
- Potential evapotranspiration: 1984 mm
- Moisture availability period: 120–150 days

Solapur

- Climate: Hot moist semi arid
- Physiography: South Western Maharashtra Plateau
- Soils: Shallow and medium loamy black soils, deep clayey black soils (Vertic Inceptisols – 60%; Orthids – 40%)
- Annual rainfall: 743 mm
- Potential evapotranspiration: 1801 mm
- Moisture availability period: 90–120 days

Soil and water conservation

Solapur

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

Beed, Osmanabad, Jalna

- Compartmental 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* lopping mulch at 3.5 t/ha

Crop management

Beed, Jalna, Osmanabad, Solapur

- Varieties: Bhima, DSH-129, MKH-11, Shikha and JSI-73
- Seed rate: 12 kg/ha

- Planting pattern: 45x20 cm
- Nutrient management: 30 kg N + 15 kg P₂O₅/ha. All to be applied as basal

Pest management

- Aphid control:
 - Use of Bhima moderately aphid tolerant
 - Sowing of safflower in second fortnight of September
 - Use of Neem seed extract 5 % spray
 - Spraying of 0.3 % Dimethoate on the basis of economic threshold level (ETL)
- Wilt disease:
 - Clean cultivation
 - Crop rotation
 - Use certified seed of resistant variety
 - Seed treatment with Thiram @ 2 g/kg seed
- Leaf spots:
 - Spray with Mancozeb @ 0.25 %
 - Avoid early sowing

Some other important practices

- Medium deep to deep, well drained soils are suitable
- Sowing by second fortnight of September
- Protective irrigation at 35 days after sowing
- Inter-cultivation – Two hoeing at 3rd and 5th week after sowing
- Seed treatment with Thiram/ Captan – 3 g and *Azotobacter* – 25 g

Suitable cropping systems

Beed, Jalna, Osmanabad, Solapur

- *Rabi* Sorghum – safflower, Safflower – chickpea

Intercropping System

- Chickpea + safflower (3:1 or 2:1)
- Wheat + safflower (3:1 or 2:1)
- Linseed + safflower (3:1 or 4:2)
- Coriander + safflower (3:1)

***Rabi* – *rabi* rotation**

- *Rabi* sorghum - safflower
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- Sorghum for fodder followed by chickpea or safflower

Two year rotations:

- Safflower or chickpea - *rabi* sorghum
- *Rabi* sorghum or chickpea - safflower

Some other important practices

- Sequence cropping
- Greengram - safflower
- Blackgram - safflower
- Hybrid sorghum - safflower*
- Groundnut - safflower*
- Sesame - safflower
- Sunflower - safflower

* As a contingent practice depending on timely receipt and/or availability of favourable soil moisture conditions.

Seeding time

The optimum time of seeding stipulated for different safflower growing areas in Maharashtra advantage of first soaking rains received in September/October is as follows:

Region	Recommended seeding time
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Assured rainfall areas of Western Maharashtra and Marathwada	Last week of September to mid October
Vidarbha Rainfed	Last week of September to first week of October

Farm implements/ tools

Beed, Jalna, Osmanabad, Solapur

- 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 former: Bund formers were tested and found suitable for compartmental bunding. Rs.1050/-
- Baliram plough: Identified for moisture conservation practices like ridges and furrows and compartmental 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/-

Alternate farming systems

Beed, Jalna, Solapur

- Agri-Horti system - Ber (5x5 m) + moth bean (8 lines) (30x10 cm)
- Silvipasture: *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*, *Albizzia lebbeck*, *Dalbergia sissoo*, Neem, *Prosopis cineraria*
- Fruit: Ber, date palm, jamun, fig, phalsa, karonda
- Medicinal/ aromatic plants: *Plantago ovata*, *Cassia angustifolia*, Safed musli, *Papaver somniferum*
- Vegetables: Clusterbean, cowpea, amaranthus, round melon
- Animal component: Female buffalo/ sheep, goat

Osmanabad

- Silvipasture: *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: *Dalbergia sissoo*, *Albizzia lebbeck*, *Anogeissus latifolia*, *Sesbania*, *Stylosanthes*, *Marvel-8 grass*
- Fruit: Ber, custard apple, pomegranate, amla + *kharif* spreading crops
- Medicinal/ 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

Alternate land use system

Beed, Jalna, Solapur

- Lands < 22.5 cm depth of soil should be cultivated with agro forestry and dryland horticulture including ber, custard apple, amla, wood apple, jambhul etc.
- Silvipastoral system of Subabul + Marvel-8 with cutting of the alternate trees at 7th year onwards for fuel is also recommended.

Osmanabad

- 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.
- Silvipastoral 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.

Contingent planning

Beed, Jalna, Osmanabad, Solapur

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

Summary

The three centres of origin, for safflower (*Carthamus tinctorius L.*), are India, Afghanistan and Ethiopia. Decandole was of the opinion that Arabia was the most probable centre of origin.

The safflower plant is highly branched, herbaceous, thistle-like annual, varying in height from 30 to 160 cm. It has many branches each terminating in a flower. The inflorescence is broad, flat or slightly curved and densely bristled owing to the presence of numerous floral tracts. The flowers are yellow to red, containing 20 individual flicrets, each of which produces a seed.

The crop is grown during *rabi* primarily as a rainfed crop, but in some areas it is raised under irrigation. At all stages of growth of the crop, excessive rainfall or humidity increases damage from fungal diseases. Waterlogging due to poor drainage or prolonged rains even for relatively short periods can cause substantial fall in seed-yield. Being drought-resistant, it is cultivated on all types of soil, including sandy soil, but it thrives best on water-retentive black soils and alluvial loams. The crop is fairly resistant to saline condition.

Safflower is grown mostly as a mixture with wheat, barley, chickpea and *rabi* sorghum, three rows of safflower being planted after every nine, 12 or more rows of the main crop. Sometimes, it is sown as border rows surrounding the crops of wheat, *rabi* sorghum, etc., because being spiny, it protects the main crop against cattle trespass. As a pure crop, it is rotated with wheat, chickpea and *rabi* sorghum. Occasionally, it is grown as a second crop after any quick-maturing *kharif* crop, e.g. greengram, blackgram, groundnut, coriander, etc. The number of ploughings should be as few as possible and be aimed at preserving the maximum amount of soil moisture. One or two ploughings with a country plough will be sufficient to remove the weeds and break the clods. Sowing is generally done in September and October. The seed-rate adopted varies from 5 to 12 kg/ha, depending upon the soil fertility and the nature of the crop (pure or mixed). When grown in strips, a row spacing of 45 cm is adopted. Plants too close tend to have thinner stems or wear a superficial root-system, with a reduced number of flowers.

In general, the pure crop is given one or two weedings, combined with hoeings on the 20th and the 45th day after sowing. When grown in strips, a row spacing of 45 cm is adopted.

The application of 20-40 kg of nitrogen per hectare results in a substantial increase in yield. The mixed crop shares the preparatory tillage, manuring and cultivation given to the main crop. When the plants have developed the central flowering head, they are topped to promote branching, flowering and seed production.

The safflower aphid, thrips and the flower bud fly are the serious pests of the crop. Spraying the crop with 0.1% Fenithion, 0.03% Dimethoate and 0.07% Endosulfan is recommended for controlling aphids, thrips and budfly, respectively. Rust, alternaria leaf spot and root-rot are the important diseases of safflower. The growing of resistant varieties is recommended to avoid damage from these diseases.

The crop matures in 4 or 5 months after sowing. The ripe plants are either cut or pulled out, stacked for a few days to dry, threshed by cutting with sticks, and the resulting material is winnowed to obtain clean seeds. The average yield of the pure crop is 400-500 kg of seed per hectare, whereas that of a mixed crop is about 100 kg.

Technologies for other safflower growing rainfed regions are given below:

Andhra Pradesh	Hybrids	:	DSH-129, MKH-11
	Varieties	:	Manjira, Sagar Muthyalu, NARI-6
Madhya Pradesh	Hybrids	:	DSH-129, MKH-11
	Varieties	:	JSF-1, JSI-7, NARI-6, JSI-73
Orissa	Hybrids	:	DSH-129, MKH-11
	Varieties	:	NARI-6, A-1
Bihar	Hybrids	:	DSH-129, MKH-11
	Varieties	:	S-144, A-300, A-1, NARI-6, Sagar Muthyalu

Chattisgarh	Hybrids	:	DSH-129, MKH-11
	Varieties	:	JSF-1, JSI-7, NARI-6
Uttar Pradesh	Hybrids	:	DSH-129, MKH-11
	Varieties	:	Malviya Kusum, NARI-6, Type-65
Tamil Nadu	Hybrids	:	DSH-129, MKH-11
	Varieties	:	K-1, CO-1, NARI-6
Rajasthan	Hybrids	:	DSH-129, MKH-11
	Varieties	:	A-1, NARI-6

Suitable Cropping Systems

Intercropping

State	Suggested intercropping system	Row proportion of main and intercrop
Andhra Pradesh	Chickpea + safflower	3:1 or 2:1
	Wheat + safflower	3:1 or 2:1
	Coriander + safflower	3:1 or 2:1
	Linseed + safflower	3:1 or 2:1
Madhya Pradesh	Mustard + safflower	6:2
	Toria + safflower	6:2
	Chickpea + safflower	2:1 or 6:2 or 4:2
	Linseed + safflower	2:1 or 6:2
	Amaranthus + safflower	6:2
Chattisgarh	Chickpea + safflower	2:1 or 6:2 or 4:2
	Linseed + safflower	2:1 or 6:2
	Mustard + safflower	6:2

- Keep the seed rate of base crop same as per the prevailing recommendations for pure crop. For the intercrop component, follow seed rate based on its actual row proportion in the system. For example, for a 3:1 combination of chickpea and safflower, use only 25% of the normal seed rate suggested for the entire crop of safflower.
- For deriving maximum benefit from specific intercropping system, avoid too wide an interval between main crop and safflower. Seed safflower at closer intervals of 2:1 or 3:1 or their multiples depending on seeding devices available in a region.
- In chickpea + safflower and linseed + safflower intercropping system in Malwa plateau of Madhya Pradesh and chickpea + safflower and sorghum + safflower and sorghum + safflower intercropping systems in scarcity zone of Maharashtra, apply 100% recommended fertilizer to main as well as intercrop based on the area occupied by each crop to get highest returns.

Sequence cropping

Regions	Crop sequence
Northern Telangana of Andhra Pradesh (parts of Ranga Reddy and Mahaboobnagar district, Adilabad, Medak and Nizamabad)	Greengram - safflower Maize - safflower Hybrid sorghum - safflower* Sesame - safflower
Malwa plateau of Madhya Pradesh	Soybean - safflower* Maize - safflower Groundnut - safflower
ChattisgarhBundelkhand region of Uttar Pradesh	Upland rice - safflower Soybean - safflower Cowpea (fodder)- safflower Greengram - safflower Hybrid sorghum - safflower

Regions	Crop sequence
Eastern Uttar Pradesh	Upland rice-Safflower** Hybrid pearl millet - safflower Greengram - safflower Blackgram - safflower Sesame - safflower
Plateau region of Bihar	Upland rice - safflower Maize - safflower**
Medium and uplands of Orissa South-eastern Rajasthan (Udaipur and adjoining areas)	Upland rice - safflower Greengram - safflower Blackgram - safflower Maize (fodder) - safflower Cowpea (fodder) - safflower Cowpea (vegetable)- safflower

* As a contingent practice depending on timely receipt and/or availability of favourable soil moisture conditions.

** As a contingent practice or alternatively with pre-plant irrigation if conditions warrant.

Seeding time

The optimum time of seeding stipulated for different safflower growing areas taking advantage of first soaking rains received in September/October is as follows:

Region	Recommended seeding time
Andhra Pradesh	
Coastal and Rayalseema areas	October
Telangana	Late September or early October
Gujarat	Last week of October to first week of November
Madhya Pradesh	
Malwa plateau	Last week of September to second week of November
Chattisgarh	Second week of October to second week of November
Orissa	Second week of September to mid October
Uttar Pradesh Rainfed	Second to third week of October
Rajasthan and Tamil Nadu	Early to mid October
Bihar	Second week of October

Important practices for all safflower growing regions

Pre-soaking

- Seeds should be treated with Thiram, Captan or Bavistin @ 3g/kg seeds before sowing to prevent losses from seed and soil borne diseases.
- In Chattisgarh, presoak the seeds in pure water for 24 to 48 hours and shade dry for about 4 hours. Thereafter, treat the seeds with fungicide before sowing.

Seed treatment

Seed treatment with mixed inoculation of *Azotobacter* and *Azospirillum* (25 g/kg seed) could effectively substitute 50% of recommended N needs of safflower amounting to 20 kg/ha under rainfed conditions.

Seeding depth and devices

In scarcity zone of Maharashtra, border method of planting (skipping one row after every two rows and opening a furrow in the skipped row) and in Telangana region, tied ridges and furrow system and closing the furrow every 10 m helps in better soil moisture conservation and thereby to get higher yields of safflower.

Many a times, establishment of optimum stand is a serious problem in several non-traditional areas such as in Madhya Pradesh, Chattisgarh, Gujarat, Uttar Pradesh, Bihar, Orissa and North Western India. Under such a situation, devices which could place the seed in the moist zone as for example single row dryland deep-furrow seeder or corn planter with adjustable row opener in plateau region of Bihar (Ranchi), Malavya seed drill in eastern Uttar Pradesh should be preferred.

Points to be considered for successful double cropping in drylands involving safflower

- Choose short duration hybrids/high yielding varieties of cereals and legumes to ensure timely planting of second crop of safflower when the soil moisture in the seed zone is adequate. Safflower performs better when it succeeds a short duration grain legume than a cereal.
- Avoid deep or frequent tillage after harvest of *kharif* crops as it promotes loss of moisture. Follow minimum tillage or if possible zero tillage to achieve satisfactory plant stand.
- Take up *kharif* sowing immediately after the onset of monsoon so as to vacate the land well in time for *rabi* sowings.
- Avoid *kharif* cropping in traditional *rabi* areas if the onset of south west monsoon is delayed as it will hinder timely planting of safflower.
- Adopt relay cropping wherever possible.
- Adopt higher seed rates of 15 to 20 kg/ha to overcome the problems of inadequate moisture in the seed zone and the consequent problems of germination and emergence.
- Place safflower seed in the moist zone by using appropriate seeding devices.

Crop rotations in monocropped areas

Continuous cropping of safflower encourages build up of fungal diseases (wilts, root rots and foliar diseases) besides adversely affecting the long-term soil productivity and hence should be avoided. Rotate safflower with prevailing *kharif/rabi* crops in the region without fear or inhibition. However, cultivation of cotton after safflower or *vice-versa* should be avoided as it results in poor yields and inefficient exploitation of nutrients because of their identical rooting habits. Further, this rotation increases build up of *Verticillium* wilt. Inclusion of a grain legume in the rotation should be preferred as it not only benefits safflower but also improves soil fertility.

Thinning

Thin excess seedlings within 10-15 days after emergence and maintain the desired plant to plant spacing.

Important insect pests and their control

Insect	Nature of damage	Control method by agronomic management	Chemical control methods
Aphids (<i>Uroleucon compositae</i> Theobald)	During pre-flowering stage both nymphs and adults suck the cell sap from shoot apices, peduncles, leaves and stem, secrete a honey dew like secretion on upper surface of the leaves and plant parts forming a black sooty mould which hinders photosynthetic activity resulting in stunted growth. Finally plants dry.	Avoid delayed planting	Spray Dimethoate (0.05%) or Methyl Parathion (0.05%) or Monocrotophos (0.05%) or Chlorpyrifos or Endosulfan (0.05%) or alternatively dust Quinalphos (1.5%) or Methyl Parathion (2.5%) or Malathion (5%) or Endosulfan (4%) 40 and 60 days after sowing. Use 500 l of spray mixture and 20 kg dust formulation/ha. In transitional tract of Karnataka and scarcity zone of Maharashtra, one spray zone of NSKE (5%) a week after first incidence followed by the spray of recommended insecticide 15 days later gives good control of safflower aphid.

Insect	Nature of damage	Control method by agronomic management	Chemical control methods
Capsule borer (<i>Helicoverpa armigera</i> Hubner)	During early stages of growth, it damages leaves and shoot apices. Then it is often noticed on capitula at later stage. Typical symptoms are perforated leaves and involucre bracts, partially or completely eaten capitula. Dried black excreted pellets are seen on the infested parts and the larva is seen on the holes of the capsule.	Avoid chickpea as intercrop. Hand pick and destroy caterpillars.	Spray Dimethoate (0.07%) or Endosulfan (0.07%) at the rate of 500 l of spray mixture/ha.

Important diseases and their control

Disease	Nature of damage	Control method by agronomic management	Chemical control methods
Alternaria leaf spot (<i>Alternaria carthami</i> Chowdhary)	Severe in irrigated crop and in warmer areas particularly under frequent showers of cyclonic cloudy weather. Seed may rot and damping off of seedlings occurs. Brown discoloration appears on the stem; dark brown spots with concentric rings upto 1 cm in diameter appear on the leaves which later develop into large lesions. Later, hole is formed at the spotted patches.	<ul style="list-style-type: none"> Seed the crop at the recommended time. Avoid growing in low-laying areas and flooding under irrigation Avoid continuous growing of safflower Remove and destroy the diseased plants Do not delay irrigation until the crop exhibits moisture stress symptoms 	Spray Mancozeb (0.25%) immediately after disease is noticed and repeat the spray 15 days later depending on the intensity disease.
Ramularia leaf spot (<i>Ramularia carthami</i> Zaprometov)	More prevalent in irrigated areas of western Maharashtra and transitional belt of Karnataka. Round and regular spots of 100 mm or more in diameter occur on both sides of leaves, whitish dense mass of conidia remain at the centre which reflects light, dry spots are brown in colour.	<ul style="list-style-type: none"> Seed the crop at the recommended time Avoid growing in low-laying areas and flooding under irrigation Avoid continuous growing of safflower Remove and destroy the diseased plants Do not delay irrigation until the crop exhibits moisture stress symptoms 	Spray Mancozeb (0.25%) immediately after disease is noticed and repeat the spray 15 days later depending on the intensity disease.
Rust (<i>Puccinia carthami</i> Corda)	Seedling infection causes twisting towards one side. Chestnut brown pustules are formed on hypocotyl leading to collapse of seedling. On older plants gridling and hypertrophy of the stem base may occur. Small, powdery chestnut brown pustules of 1-2 mm in size develop on leaf surface which later turn black.	<ul style="list-style-type: none"> Seed the crop at the recommended time Avoid growing in low-laying areas and flooding under irrigation Avoid continuous growing of safflower Remove and destroy the diseased plants Do not delay irrigation until the crop exhibits moisture stress symptoms 	One or two sprays of Calixin (0.05%) or Dithane M-45 (0.25%) at 15 days interval

Disease	Nature of damage	Control method by agronomic management	Chemical control methods
Wilt (<i>Fusarium oxysporum</i> f. sp. <i>carchami</i>)	Yellowing of leaves on one side of plants starts particularly from lower leaves followed by wilting that progresses upwards. Lesion at soil line is the first symptom noticed which extends inside and affects the vascular system. Plant starts to wilt, drooping more often. Infected heads have aborted seeds.	<ul style="list-style-type: none"> Seed the crop at the recommended time Avoid growing in low-laying areas and flooding under irrigation Avoid continuous growing of safflower Remove and destroy the diseased plants Do not delay irrigation until the crop exhibits moisture stress symptoms 	Treat the seed with Carbendazim @ 0.1-0.2%
Root rot (<i>Rhizoctonia bataticola</i>)	Dark cortical lesions occur slightly below or at the soil level on the stem, which later extend upwards. Lesions frequently girdle the stem. Root development is reduced and finally seedlings die.	<ul style="list-style-type: none"> Seed the crop at the recommended time Avoid growing in low-laying areas and flooding under irrigation Avoid continuous growing of safflower Remove and destroy the diseased plants Do not delay irrigation until the crop exhibits moisture stress symptoms 	Treat the seed with Thiram or Dithane M-45 @ 0.2%.

Cycocel application

Spray Cycocel @ 500 ppm at flower initiation to get higher seed yield and returns from safflower. Use about 300 l of spray solution per hectare.

Bird Damage

Birds, particularly parrots pose a serious problem to safflower when it is raised in isolated pockets as in non-traditional areas. To minimize damage from birds, take up safflower cultivation in large contiguous blocks. Safeguard the crop from bird damage during the period from seed filling to physiological maturity which extends by about three weeks through effective bird scaring particularly in the morning and evening hours.

Safflower for aberrant weather

Delayed rains

- It is more profitable to go in for safflower whenever there are late rains in October/November.
- Similarly, in several single-cropped *rabi* areas, the occurrence of prolonged dry weather conditions immediately after planting coupled with insufficient moisture at seedling time result in poor and uneven plant stand and/or near failure of early sown *rabi* crop. In such a case, scrap the early sown *rabi* crop and resow with safflower taking the advantage of favourable rains in October/ early November.

Extended monsoon

- Large areas from otherwise traditionally *kharif* cropped soils kept fallow in *rabi* for want of adequate moisture in seeding zone. Whenever favourable rains are received immediately after harvest of *kharif* crops sometimes in late September/October and soil moisture adequate for second crop, take full advantage of the situation and raise 2 crops in place of a single crop by planting safflower immediately after harvest of *kharif* cereals (sorghum, upland rice, pearl millet, maize, etc..) legumes (Greengram, Blackgram, groundnut, etc..) and others (sesame)

- Several light and medium textured soils in the potential safflower growing areas of Maharashtra, Karnataka, Andhra Pradesh, Madhya Pradesh, etc., which are normally cropped in *kharif* can be put to productive use by taking safflower either as a compensatory crop in the event of total failure of *kharif* crops whenever near/above normal seasonal conditions prevail in *rabi*. In case plantings are delayed and/or soil depth is limited, use higher seed rate than normal to curtail excessive vegetative growth of safflower.

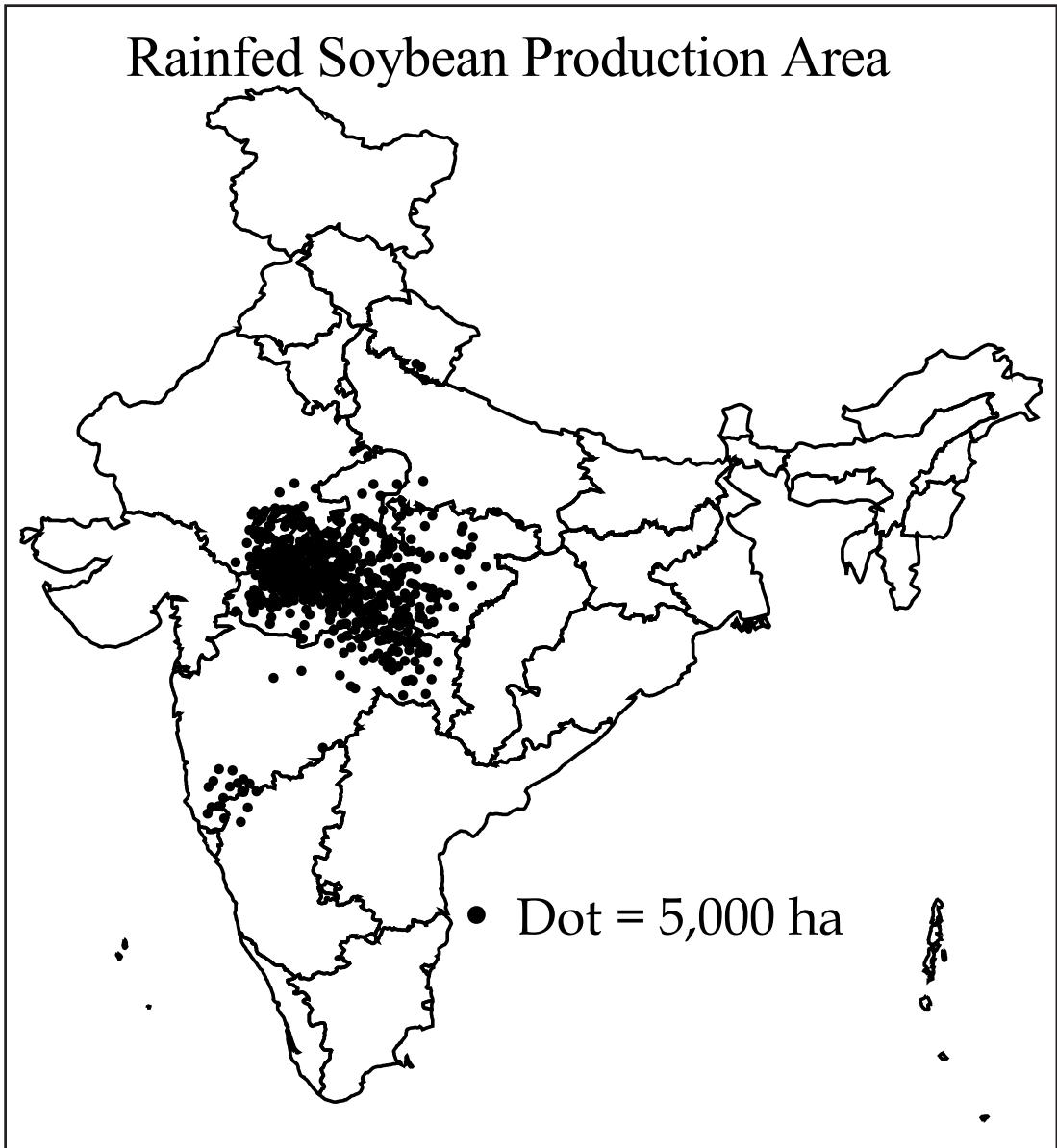
Insufficient rainfall and/or stored moisture in *rabi*

- Whenever stored moisture is inadequate and post-sowing rains far and few, give either pre-planting irrigation from runoff water collected in dugout ponds or any source, or alternatively one life saving irrigation at elongation/flowering or earlier if crop shows symptoms of moisture stress.
- In situations where water levels in wells/tanks/reservoirs are limited and favourable and timely rains are received in *rabi*, plant safflower in place of other high water requiring crops like wheat to achieve efficient use of scarce water resources over a larger command area and obtain higher returns per unit area and unit amount of water.

Harvesting and threshing

The crop is ready for harvest when the leaves and most of bracteoles except a few on last formed flower heads become dry and brown. Harvest the crop preferably in the early hours when shattering would be minimum and spines relatively soft. Cut plants with the help of sickles at the base or wherever possible uproot (black soils) by pulling and stack them in the field in the form of small and well pressed heaps until they are fully dried.

Prioritised cultural options				
State	District	Prioritised Options	Average yield (kg/ha)	Expected yield (kg/ha)
Karnataka	Bijapur, Raichur	<i>In situ</i> water management technologies and adoption of improved crop management techniques to reduce yield gap	420	480 to 505
	Gulbarga	-do-	500	545 to 570
	Dharwad	Better adoption of crop management technologies	685	750 to 790
Maharashtra	Beed	Adoption of improved crop management techniques to increase productivity and <i>insitu</i> water management technologies	250	285 to 300
	Ahmednagar	<i>In situ</i> water management technologies and adoption of improved crop management techniques to reduce yield gap	420	480 to 505
	Pune	-do-	500	545 to 570
	Osmanabad Solapur	Adoption of improved crop management techniques to increase productivity and <i>insitu</i> water management technologies	340	385 to 410
	Parbhani	<i>In situ</i> water management technologies and adoption of improved crop management techniques to reduce yield gap	445	490 to 510
	Jalna	Adoption of improved crop management techniques to increase productivity and <i>insitu</i> water management technologies	300	345 to 360



SOYBEAN BASED PRODUCTION SYSTEM

Soybean with coverage of 6 mha and production of 6 mt has recently occupied an important place in agricultural and oil economy of India. It has revolutionized rural economy and has uplifted socio-economic status of farmers. Occupying third place in area, production and share in national kitty for edible oils, soybean is the only cost effective alternative to ameliorate pulse protein deficiency in the country. While there had been unprecedented increase in area and production (75% and 155% respectively during 1986-87 to 1993-94), the increase in productivity had been slow (91%). It is gaining more coverage in adjacent areas to Madhya Pradesh and Maharashtra and even in tribal districts in Andhra Pradesh like Adilabad. The present yield levels in these new areas are more than in Madhya Pradesh. Therefore, it is necessary to properly identify the areas that are more suitable for growing soybean. The major concern is that the yield at national level has stagnated at 1 t/ha as against 2-3 t/ha in Front Line Demonstrations and 3-4 t/ha achieved in research experiments.

The area covered is likely to stabilize around 10 mha by 2010 A.D., and 12 mha by 2020 AD. The trends in growth of productivity reveal that it may touch 12 mt by 2000 AD and above 16 mt by 2020 AD. The increasing production of soybean in other countries will offer tough competition for export. For the sustainability of the crop in India, creation of domestic market is inevitable, which in turn calls for development of products based on soya meal and consumer awareness. Also quality of soya meal is to be maintained high to compete in export market. At present the domestic utilization of soymeal is between 25-30%, mainly utilized for poultry feed and fish meal.

Soybean is grown in 3.67 mha in 202 districts. About 85% of the area (2.84 mha) is in 21 districts.

Selection criteria	No. of districts	Area under Soybean ('000 ha)	Area under Rainfed Soybean ('000 ha)	Gross Cropped Area ('000 ha)	Yield (kg/ha)
States (13)	202	3666	3574	112689	532
Agro Eco Region **	160	3483	3391	90863	569
85% Rainfed Soybean Area	21	2857	2843	11217	911

**Arid, semiarid and dry sub humid

The trends in area and yield growth rates of 21 districts is given below:

Area	Yield	State	District
Stagnant	Increasing	Madhya Pradesh	Shajhapur, Hoshangabad, Dhar, Indore, Dewas, Chhindwara, Sagar, Guna
		Maharashtra	Nagpur
		Rajasthan	Chittorgarh
Stagnant	Stagnant	Madhya Pradesh	Raisen
Increasing	Increasing	Madhya Pradesh	Ujjain, Sehore, Mandsaur, Betul, Ratlam, Seoni, Narsinghpur, Vidisha
		Rajasthan	Jhalawar

The popular soybean production systems existing in various AERs is presented below:

Agro ecoregion	Production system
Hot semi-arid central Highlands (Malwa)	Soybean– safflower Sorghum – soybean Maize – soybean
Hot sub-humid Central Highlands (Malwa and Bundelkhand)	Soybean – wheat

With an increase in soybean area, animal population has increased. Hence, quality and quantity of fodder throughout the year is a point to ponder.

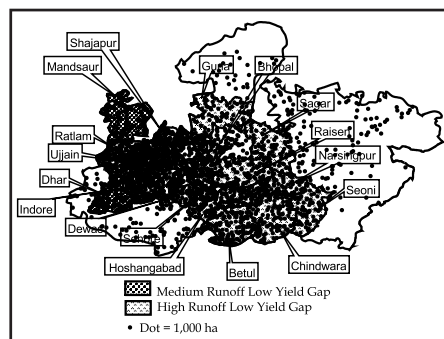
Details on associated crops and livestock are presented below:

Crops	Animals	Districts
Wheat	Goat	Narsinghpur, Seoni, Sagar, Guna, Raisen, Vidisha, Bhopal
Soybean	Female Buffalo	
Chickpea		
Lentil		
Sorghum		
Soybean	Goat	Chhindwara, Indore, Ratlam, Ujjain, Mandsaur, Dewas, Dhar,
Sorghum	Female Buffalo	Sehore, Betul, Shajhapur, Hoshangabad, Nagpur, Chittorgarh,
Maize		Jhalawar
Chickpea		

The recommendations on this crop based production system are given below state and district-wise in alphabetical order for the regions with low (< 12 %), medium (12–25 %) and high (>25 %) runoff/ surplus index, and low (<33 %), medium (33-66 %), and high (>66 %) yield gap from achievable yield (which is 70 % of potential yield based on normal rainfall, soil water holding capacity and water requirement) of soybean crop are presented

Madhya Pradesh

In Madhya Pradesh there are two districts viz. Mandsaur and Dhar under medium runoff and low yield gap region and fifteen districts viz. Ratlam, Dewas, Sehore, Shajhapur, Bhopal, Raisen, Sagar, Betul, Chindwara, Narsingpur, Hoshangabad, Indore, Ujjain, Seoni and Guna under high runoff and low yield gap region.



State	District	Region
Madhya Pradesh	Dhar Mandsaur	Medium runoff and Low yield gap

Agro-geographic setting

Dhar

- Climate: Hot moist semi arid
- Physiography: Western Malwa Plateau
- Soils: Deep clayey black soils, shallow black soils (Vertic Inceptisols – 100%)
- Annual rainfall: 915 mm
- Potential evapotranspiration: 1692 mm
- Moisture availability period: 120-150

Mandsaur

- Climate: Hot moist semi arid
- Physiography: Western Malwa Plateau
- Soils: Deep clayey and shallow black soils (Vertic Inceptisols - 100%)
- Annual rainfall: 962 mm
- Potential evapotranspiration: 1601 mm
- Moisture availability period: 120-150 days

Soil and water conservation

Dhar, Mandsaur

- 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 a 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 to increase life of water storage bodies.
- Construct water harvesting tank to retain the excess run off from the watershed area to use stored water for irrigation purpose.
- Silpaulin (a plastic material) of 90 – 120 gsm has been found to be an effective lining material for farm ponds used for water harvesting purpose.
- Use vegetative barriers to strengthen the mechanical bunds at suitable vertical intervals in order to reduce run off and associated soil losses from the cultivated fields.
- Develop a sort of terracing to break the continuity of undulating slope and 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, is 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 %.
- Off-season shallow tillage is important not only in controlling the weeds but also in helping entry of rain water.
- Develop a sort of terracing to break the continuity of undulating slope to reduce the changes of degrading cultivated fields in to gullied one.
- Provide *in-situ* soil mulch by operating bullock drawn *dora* to fill up the cracks, to conserve the 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

Dhar, Mandsaur

- Varieties: JS-335, JS-71-05, JS 90-41, JS 93-05, PK 416 Pusa 16, Ahilya 1 (NRC-2), Ahilya 2 (NRC -12), Ahilya 3 (NRC - 7), Ahilya 4 (NRC - 37) MAUS-47, MAUS 61-2, Indira soya 9, PK 472, MACS 58, MAUS 81

- Seed rate: 75 kg/ha
- Planting pattern: 30–40x15 cm
- Nutrient management
 - Recommended dose of fertilizer 20:60:20:20 N,P₂O₅, K₂O, S Kg/ha.
 - Half of the recommended doses of fertilizer (20 kg N + 13 kg P/ ha) in conjunction with 6 t FYM/ha for soybean – safflower sequence is recommended for achieving highest sustainable productivity and building up of organic carbon in the soil.
 - Apply 40 kg N in low N available soils
 - Apply 4- 6 t farm yard manure/ha + 30 kg N+ 40-50 Kg P₂O₅ + 20 kg K₂O + 30 kg sulphur/ha in medium deep and deep soils
- Pest management
 - Herbicides: Fluchloralin @ 2 l/ha or Trifluralin @ 2.1 l/ha as Preplant Incorporation or Alachlor @4 l/ha or Metolachlor @ 2 l/ha or Pendimethalin @ 3.33 l/ha or Clornozone @ 2 l/ha as Pre-emergence followed by one dora after 20 days after sowing or Imazathapyr @ 1 l/ha or fenaxy prop P-ethyl 750 ml/ha or Chlorimuron ethyl @ 36 g/ha as postemergence (15-20 days after sowing)
 - Apply Trifluralin @ 2-2.5 l in 750 l of water/ha presowing application after 30 days interculture
 - Effective insect pest control during 30 days of sowing could minimize losses to 10%
 - DS-76-1, DS-75-12-1 and PK – 695 are yellow mosaic, root rot and bacteria pustules tolerant
 - Soybean should be kept weed free at least upto 45 – 60 days after sowing.
 - Pre-emergence application of Trifluralin 35 EC @ 1 Kg ai/ ha or Pendimethalin 30 EC @ 1 kg ai/ha
 - Post emergence, Imazethapyr @ 75 g ai/ha spray at 20 to 25 days after sowing

Some other important practices

- Sowing 25th June to 7th July. The crop planted in last week of June yields maximum
- Seed inoculation with *Brady rhizobium japonicum* @ 5 g/kg seed economical
- Dual inoculation of *B. japonicum* with phosphorous solubilizing bacteria increased yield by 17%
- Narrow row plentary of 22.5 cm with 50% dose of PPI/PE herbicide profitable for weed control.
- Seed treatment with 2 g Thiram + 1 g carbendazim per kg seed followed with *Bradyrhizobium japonicum* before sowing
- Shallow soils (upto 25 cm): cultivation in shallow soils to be discourage, if cultivation of soybeen is taken, the early varieties like MAUS 81, Ahilya 2, MAUS 47, JS 71-05 and Farmers variety 'Samrat' can be taken
- Medium deep soils (25 – 45 cm): JS –71-05, JS 80-21, JS-335, JS-81-1498, PK-472, NRC-2, JS-81-16-08, NRC-12, NRC - 37
 - Intercropping of Soybean + pigeonpea in 4:2 row ratio
- Deep soils (more than 45 cm)
 - Soybean – chickpea
 - Soybean – linseed
 - Soybean – safflower
 - Soybean – rapeseed/ mustard
 - Soybean – sunflower

Suitable cropping systems

Dhar, Mandsaur

- Soybean + pigeonpea (4 : 2) intercropping
- Soybean - safflower sequence in normal condition with 30 and 45 cm row spacing, respectively.
- Soybean - chickpea

Farm implements/ tools

Dhar, Mandsaur

- Suitable implements for seedbed preparations:
 - Meston Plough
 - Iron Bakhar
- Suitable implements for sowing operations:
 - Mostly the sowing operation is done using seed drills
 - For planting intercrops, intercrop seed drill is available
 - 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

Dhar, Mandsaur

- Fodder/ green biomass: *Dichrostachys cinerea*, *Albizzia amara*, *Faidherbia albida*, *Hardwickia binata*, *Cassia*, *Leucaena leucocephala*, *Albizzia 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, amaranthus, round melon
- Animal component: Male/female cattle, female buffaloes, sheep, goat, dairy

Contingent planning

Dhar, Mandsaur

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 and Sathi, are).
 - Pigeonpea - (under deep soils preferred varieties are ICPL 151, T-21, Kh-2, and ICPL 87 and ICPL 88039)
 - Sunflower – Morden, Surya and Manjira

- Sesame – Bhadeli, TKG 22 and TKG 37
 - Cowpea – Pusa Komal and Pusa Baisakhi
 - Castor – Gauch and Varuna
 - Fodder crops – *Sorghum sudanensis*, maize (African tall), dinanath grass and pearl millet.
- **1st to 15th August**
 - Sunflower – Morden, Surya, Manjira and any hybrids
 - Sesame – Bhadeli, TKG 22 and TKG 37
 - 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 and Sharda
 - Sunflower – Morden, Surya and Manjira
 - Sesame – Bhadeli, TKG 22, and RT-46
 - Rajgira –CO-1 and CO-2.
 - Castor- Gauch and Varuna
 - Fodder crops – Barley, oats, maize (African tall), safflower and sunflower

State	District	Region
Madhya Pradesh	Betul Bhopal Chindwara Dewas Guna Hoshangabad Indore Narsingpur Raisen Ratlam Sagar Sehore Seoni Shajhapur Ujjain	High run off and Low yield gap

Agro-geographic setting

Betul

- Climate: Hot dry sub humid
- Physiography: Satpura ranges
- Soils: Shallow and medium loamy to clayey black soils, deep clayey black soils (Vertic Inceptisols – 85%; Vertisols – 15%)
- Annual rainfall: 1129 mm
- Potential evapotranspiration: 1370 mm
- Moisture availability period: 150-180 days

Bhopal

- Climate: Hot dry sub humid
- Physiography: Malwa Plateau
- Soils: Medium and deep clayey black soils, shallow loamy black soils (Vertisols – 60%; Vertic Inceptisols – 40%)
- Annual rainfall: 1211 mm
- Potential evapotranspiration: 1554 mm
- Moisture availability period: 150-180 days

Chindwara

- Climate: Hot moist sub humid
- Physiography: Satpura ranges, South Madhya Pradesh
- Soils: Shallow to deep loamy to clayey mixed red and black soils (Vertic Inceptisols – 85%; Vertisols – 15%)
- Annual rainfall: 1094 mm
- Potential evapotranspiration: 1427 mm
- Moisture availability period: 180-210 days

Dewas

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

Guna

- Climate: Hot dry/ moist semi arid
- Physiography: Vindhyan scraplands
- Soils: Deep loamy and clayey mixed red and black soils, medium and deep clayey black soils, shallow loamy black soils (Vertic Inceptisols – 100%)
- Annual rainfall: 1222 mm
- Potential evapotranspiration: 1511 mm
- Moisture availability period: 120-150/ 150-180 days

Hoshangabad

- Climate: Hot dry sub humid
- Physiography: Narmada valley
- Soils: Medium and deep clayey black soils, shallow loamy black soils (Vertic Inceptisols – 100%)

- Annual rainfall: 1385 mm
- Potential evapotranspiration: 1597 mm
- Moisture availability period: 150-180 days

Indore

- Climate: Hot moist semi arid
- Physiography: Western Malwa Plateau
- Soils: Deep clayey black soils, shallow black soils (Vertic Inceptisols – 100%)
- Annual rainfall: 1054 mm
- Potential evapotranspiration: 1814 mm
- Moisture availability period: 120-150 days

Narsinghpur

- Climate: Hot dry sub humid
- Physiography: Satpura ranges
- Soils: Medium and deep clayey black soils, shallow loamy black soils (Vertisols – 80%; Vertic Inceptisols – 20%)
- Annual rainfall: 1690 mm
- Potential evapotranspiration: 1430 mm
- Moisture availability period: 150-180 days

Raisen

- Climate: Hot dry sub humid
- Physiography: Malwa Plateau
- Soils: Medium and deep clayey black soils, shallow loamy black soils (Vertic Inceptisols – 80%; Vertisols – 20%)
- Annual rainfall: 1595 mm
- Potential evapotranspiration: 1527 mm
- Moisture availability period: 150-180 days

Ratlam

- Climate: Hot moist semi arid
- Physiography: Madhya Bharat Plateau
- Soils: Deep clayey black soils, shallow black soils (Vertic Inceptisols - 100%)
- Annual rainfall: 1078 mm
- Potential evapotranspiration: 1521 mm
- Moisture availability period: 120-150 days

Sagar

- Climate: Hot dry/ moist semi arid
- Physiography: Malwa Plateau

- Soils: Deep loamy and clayey mixed red and black soils, Medium and deep clayey black soils, shallow loamy black soils (Vertic Inceptisols – 50%; Vertisols – 50%)
- Annual rainfall: 1395 mm
- Potential evapotranspiration: 1543 mm
- Moisture availability period: 120-150/ 150-180 days

Sehore

- Climate: Hot dry sub humid
- Physiography: Malwa Plateau
- Soils: Medium and deep clayey black soils, shallow loamy black soils (Vertic Inceptisols – 60%; vertisols– 40%)
- Annual rainfall: 1169 mm
- Potential evapotranspiration: 1602 mm
- Moisture availability period: 150-180 days

Seoni

- Climate: Hot moist sub humid
- Physiography: South Central Madhya Pradesh Plateau
- Soils: Shallow to deep loamy to clayey mixed red and black soils (Vertic Inceptisols – 85%; Vertisols – 15%)
- Annual rainfall: 1447 mm
- Potential evapotranspiration: 1421 mm
- Moisture availability period: 180-210 days

Shajhapur

- Climate: Hot dry/ moist semi arid
- Physiography: Malwa Plateau
- Soils: medium and deep clayey black soils, shallow loamy black soils (Vertic Inceptisols – 90%; Vertisols – 10%)
- Annual rainfall: 1117 mm
- Potential evapotranspiration: 1643 mm
- Moisture availability period: 120-150/ 150-180 days

Ujjain

- Climate: Hot moist semi arid
- Physiography: Western Malwa Plateau
- Soils: Deep clayey black soils, shallow black soils (Vertic Inceptisols – 100%)
- Annual rainfall: 1088 mm
- Potential evapotranspiration: 1656 mm
- Moisture availability period: 120-150 days

Soil and water conservation

Betul, Bhopal, Chindwara, Dewas, Guna, Hoshangabad, Indore, Narsinghpur, Raisen, Ratlam, Sagar, Sehore, Seoni, Shajhapur, Ujjain

- 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 a 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 to increase life of water storage bodies.
- Construct a water harvesting tank to retain the excess run off from the watershed area to use stored water for irrigation purpose.
- Silpaulin (plastic material) of 90 – 120 gsm has been found to be an effective lining material for farm ponds used for water harvesting purpose.
- Use vegetative barriers to strengthen the mechanical bunds at suitable vertical intervals in order to reduce run off and associated soil losses from the cultivated fields.
- 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 be 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%.
- Off-season shallow tillage is important not only in controlling the weeds but also in helping entry of rain water.
- Develop a sort of terracing to break the continuity of undulating slope to reduce the changes of degrading cultivated fields into gullied one.
- 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 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

Betul, Bhopal, Chindwara, Dewas, Guna, Hoshangabad, Indore, Narsinghpur, Raisen, Ratlam, Sagar, Sehore, Seoni, Shajhapur, Ujjain

- Varieties: JS-335, JS-71-05, JS 90-41, Bragg, PK 262, PK 327, PK 416, PK564, PK308, Pusa-16, PK-1024, PK 1029, SL-4, Ahilya-4(NRC-37), NRC-2, JJ 335, Indira soya-9, NRC 7, NRC 12, MAUS 47, MAUS 81, JS 93-05, NRC - 2.
- Seed rate: 75 kg/ha
- Planting pattern: 30–45x5 cm

- Nutrient management
 - 20 kg N + 60 kg P₂O₅ + 20 kg K₂O + 20 kg S/ha
 - Half of the recommended dose of fertilizer (N₂₀ P₁₃) for each of soybean and safflower in conjunction with 6 t farm yard manure/ ha for soybean – safflower sequence is recommended for achieving highest sustainable productivity and building up of organic carbon in the soil.
 - Apply 40 kg N in low N available soils in two splits
 - Apply 4 - 6 t Farm yard manure/ha + 30 kg N+ 40-50 Kg P₂O₅ + 20 kg K₂O + 30 kg sulphur/ha in medium deep and deep soils
- Pest management
 - Herbicides: Fluchloralin @ 2 l/ha or Trifluralin @ 2.1 l/ha as Pre Plant Incorporation or Alachlor @ 4 l/ha or Metolachlor @ 2 l/ha or Pendimethalin @ 3.33 l/ha or Cloronozone @ 2 l/ha as Pre emergence followed by one dora after 20 days after sowing Imazethapyr @ 1 l/ha or Quizalofop ethyl @ 1 l/ha or Fenaxy prop Pethyl 750 ml/ha or Chlorimuron ethyl @ 36 g/ha as post emergence (15-20 days after sowing)
 - Apply Trifluralin @ 2- 2.5 l in 750 l of water/ha presowing application after 30 days interculture
 - Effective insect pest control during 30 days of sowing could minimize losses to 10%
 - Soybean should be kept weed free at least upto 45 – 60 days after sowing.
 - Pre- emergence application of Trifluralin 35 EC @ 1 Kg a.i/ ha or Pendimethalin 30 EC @ 1. kg ai/ha

Some other important practices

- Sowing from 25th June to 7th July
- Seed inoculation with *Bradyrhizobium japonicum* @ 5 g/kg seed is economical
- Dual inoculation of *B. japonicum* with phosphorous solubilizing bacteria increased yield by 17%
- Narrow row planting of 22.5 cm is profitable for weed control with 50% dose of pre plant incorporation / pre emergence herbicide
- Seed treatment with 2 g Thiram+ 1 g Carbendazim per kg seed followed with *Bradyrhizobium japonicum* before sowing
- Shallow soils (upto 25 cm): cultivation in shallow soils to be discouraged, if cultivation of soybean is taken, the early varieties like MAUS 81, Ahilya 2, MAUS 47, JS 71-05 and farmers variety 'Samrat' can be taken
- Medium deep soils (25–45 cm): JS –71-05, JS 80-21, JS-335, PK-472, NRC-2, NRC-12, NRC-37
 - Intercropping of Soybean + pigeonpea in 4:2 row ratio
- Deep soils (more than 45 cm)
 - Soybean – chickpea
 - Soybean – linseed
 - Soybean – safflower
 - Soybean – rapeseed/ mustard
 - Soybean – sunflower

Suitable cropping systems

Betul, Bhopal, Chindwara, Dewas, Guna, Hoshangabad, Indore, Narsinghpur, Raisen, Ratlam, Sagar, Sehore, Seoni, Shajhapur, Ujjain

- Soybean + pigeonpea (4: 2) intercropping
- Soybean – safflower sequence in normal condition with 30 and 45 cm row spacing respectively.
- Soybean - chickpea

Farm implements/ tools

Betul, Bhopal, Chindwara, Dewas, Guna, Hoshangabad, Indore, Narsinghpur, Raisen, Ratlam, Sagar, Sehore, Seoni, Shajhapur, Ujjain

- Suitable implements for seedbed preparations:
 - Meston Plough
 - Iron Bakhar
- Suitable implements for sowing operations:
 - Mostly the sowing operation is done using seeds drills
 - For planting intercrops, intercrop seed drill is available
 - 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

Betul, Bhopal, Chindwara, Dewas, Guna, Indore, Narsinghpur, Ratlam, Shajhapur, Ujjain

- Fodder/ green biomass: *Dichrostachys cinerea*, *Albizia amara*, *Faidherbia albida*, *Hardwickia binata*, *Cassia*, *Leucaena leucocephala*, *Albizia lebbeck*
- Fruit: Ber, Pomegranate, mango, fig, tamarind
- Medicinal/ Aromatic Plants: *Withania 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

Hoshangabad, Raisen, Sagar, Sehore

- Agro – hortisystem: Mango + pea/ berseem (green fodder)/ wheat/ chickpea/ soybean
- Silvi – pastoral system: Teak + sudan grass
- Fodder/ green biomass: *Dichrostachys cinerea*, *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, amaranthus, round melon.
- Animal component: Male/ female cattle, female buffaloes, sheep, goat

Seoni

- Alley cropping – Subabul (4 m interval) - + groundnut/sesame/cowpea (grain)
- Fodder/green biomass: *Albizzia lebbbeck*, *Leucaena*, *Dalbergia sissoo*, *Azadirachta indica*, *Sesbania*, *Pongamia*
- Fruit: Ber, mango sapota, tamarind, fig
- Medicinal and Aromatic plants: *Papaver somniferum*, *Rauvolfia*, *Liquorice*, Safed musli, *Palma rosa*
- Vegetables: Tomato, okra, bottle gourd, ridgegourd, amaranthus, drumstick
- Animal component: Female and male cattle, female buffaloes, male buffaloes

Contingent planning

Betul, Bhopal, Chindwara, Dewas, Guna, Hoshangabad, Indore, Narsinghpur, Raisen, Ratlam, Sagar, Sehore, Shajhapur, Ujjain

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 and Sathi).
 - Pigeonpea - (under deep soils preferred varieties are ICPL 151, T-21, Kh-2, ICPL 87 and ICPL 88039)
 - Sunflower – Morden, Surya, Manjira and any hybrid
 - Sesame – Bhadeli, TKG 22 and TKG 37
 - Cowpea – Pusa Komal and Pusa Baisakhi
 - Castor – Gauch and Varuna
 - Fodder crops – *Sorghum sudanensis*, Maize (African tall), dinanath grass and pearl millet
- **1st to 15th August**
 - Sunflower – Morden, Surya, Manjira and any hybrid
 - Sesame – Bhadeli, TKG 22 and TKG 37
 - 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 and Sharda
 - Sunflower – Morden, Surya and Manjira
 - Sesame – Bhadeli, TKG 22, and RT-46
 - Rajgira –CO-1 and CO-2.
 - Castor- Gauch, Varuna
 - Fodder crops – Barley, oats, maize (African tall), safflower and sunflower

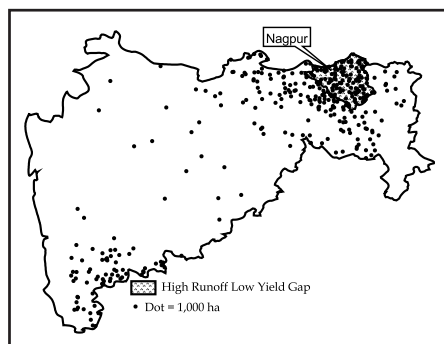
Seoni

- **June**
 - Sole crop
 - Sorghum (CSH 5, JS 1041)
 - Green Gram (K 850)
 - Blackgram (JU 2, PDU 4)
 - Groundnut (Jawahar Jyoti, M 13)
 - Inter crop
 - Sorghum + pigeonpea (4: 2)
 - Soybean + pigeonpea (4: 2)
- **July**
 - Sole crop
 - Rice (IR 50, JR 345)
 - Kodo (JK 155, JK 76, JK 136)
 - Sorghum (CSH 5)
 - Pigeonpea (NPWR -15, JA4, Asha)
 - Groundnut (Jyoti, M 12, Exotic 1-1)
 - Inter crop
 - Sorghum + pigeonpea (4: 2)
 - Soybean + pigeonpea (4: 2)
- **August**
 - Castor (Aruna)
 - Pigeonpea (No.148)
- **October**
 - Wheat (JW 17, C 306)
 - Chickpea (JG 321, JG 315)
 - Linseed (JL 23, R 552)
 - Barley (Karan 4, Jyoti)
 - Lentil (JL 1, Malika)

Maharashtra

In Maharashtra there is one district viz. Nagpur under high runoff and low yield gap region.

State	District	Region
Maharashtra	Nagpur	High runoff and Low yield gap



Agro-geographic setting

- Climate: Hot dry sub humid
- Soils: Shallow and medium loamy to clayey black soils, deep clayey black soils (Vertisols – 60%; Inceptisols – 20%; Entisols – 20%)

- Annual rainfall: 1242 mm
- Potential evapotranspiration: 2050 mm
- Moisture availability period: 150-180 days

Soil and water conservation

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

Crop management

- Varieties: JS 335, MACS - 58, NRC 2, NRC 7, NRC 37 NRC 12 PK 1029 PK 1024 Indira soya 9, MAUS 61
- Seed rate: 75 kg/ha
- Planting pattern: 30-45x5 cm
- Nutrient management: 20 kg N + 60 kg P₂O₅ +20 kg K₂O + 20 kg S/ha

Pest management

- Effective insect pest control during 30 days of sowing
- Weed free condition up to 30 days after sowing

Some other important practices

- Seed inoculation with *Bradyrhizobium japonicum* @ 5g/kg of seed
- Seed treatment with 2 g Thiram + 1 g Carbendazim per kg seed followed with *Bradyrhizobium japonicum* before sowing

Suitable cropping systems

Intercropping

- Cotton (AKH 84635) + soybean (JS -335) (1:1)
- Soybean + pigeonpea (4:2)
- Soybean + sorghum (4:2)

Sequence cropping

- Soybean - chickpea
- Soybean - rapeseed/ mustard
- Soybean - safflower

Farm implements/ tools

- 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.
- Manually operated fertilizer drill
- Bullock drawn serrated blade for intercultivation

Alternate farming systems

- Fodder/ green biomass: *Leucaena leucocephala*, *Albizzia 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, bottlegourd.
- Animal component: Male/ female cattle, female buffaloes, sheep, goat, poultry

Contingent planning

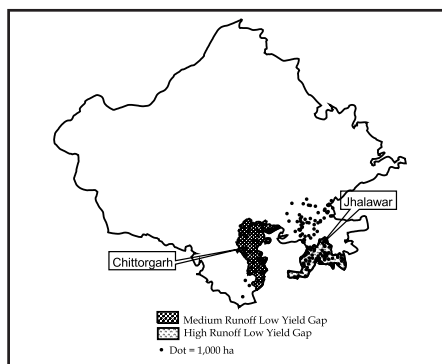
- **Regular monsoon:**
 - The regular monsoon starts by 24th meteorological week. For regular monsoon, the following recommendations stand.
- **Light soils (depth 20 to 30-35 cm)**
 - Graded bunding of lands
 - Growing of strips of erosion resistant crops (Greengram-Kopergaon/Blackgram-T-9) in the upper 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 (75 cm depth)**
 - Cotton – inter specific cultivation of *hirsutum* cotton AKA-7 with AKH 4 cotton.
 - 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.
 - 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 (Ahsa)
 - 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, chickpea are not able to sustain such stress. Therefore, use of some conditioner such as spray of urea, not exceeding to 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 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.

Rajasthan

In Rajasthan there is one district viz. Chittorgarh under medium runoff and low yield gap region and one district viz. Jhalawar under high runoff and low yield gap region.

State	District	Region
Rajasthan	Chittorgarh	Medium runoff and Low yield gap



Agro-geographic setting

- Climate: Hot moist/ dry semi arid
- Physiography: East Rajasthan uplands
- Soils: Deep loamy grey brown and alluvium, derived soils, deep clayey black soils, shallow black soils (Vertic Inceptisols – 100%)
- Annual rainfall: 885 mm
- Potential evapotranspiration: 1556 mm
- Moisture availability period: 95-150 days

Soil and water conservation

- More emphasis on *insitu* water conservation
- Increasing soil infiltration capacity and reducing soil crusting problem
- Contour furrowing
- Absorption terracing
- Contour trenches
- Inter-plot water harvesting of 1:1 cropped to un-cropped land
- Dead furrows at 3.6 m interval

Crop management

- Varieties: JS-335, JS-71-05, Punjab -1, MACS-13, Monetta, PK-472, MACS-58, Pusa-16
- Seed rate: 75 kg/ha
- Planting pattern: 30–45x5 cm
- Nutrient management: 20 kg N + 60 kg P₂O₅ + 20 kg K₂O/ha +20 kg S/ha

Pest management:

- Herbicides: Fluchloralin @ 2 l/ha or Trifluralin @ 2.1 l/ha as Pre Plant Incorporation or Alachlor @ 4 l/ha or Metolachlor @ 2 l/ha or Pendimethalin @ 3.33 l/ha or Clornozone @ 2 l/ha as Pre emergence followed by one dora after 20 days after sowing ir Imazethapyr @ 1 l/ha or Quizalofop ethyl @ 1 l/ha or Fenaxy prop Pethyl 750 ml/ha or Chlorimuron ethyl @ 36 g/ha as post emergence (15-20 days after sowing)
- Apply Fluchlorarin 0.75 g in 500 – 600 l of water/ha one day before sowing followed by light ploughing
- Effective insect pest control during 30 days of sowing could minimize losses to 10%

Some other important practices

- Seed inoculation with *Bradyrhizobium japonicum* is economical
 - Seed treatment with 2 g Thiram + 1 g Carbendazim per kg seed followed with *Bradyrhizobium japonicum* before sowing
 - Seed treatment with Thiram 2 gm + Bavistin 1 g/ kg seed and also rhizobium culture
 - Sow immediately at the onset of monsoon interrow spacing 30 cm while intra row spacing is 7.5 cm for early maturing varieties, 10 cm for medium duration varieties and 12.5 cm for late duration varieties
 - First interculture 25-30 days after sowing

Farm implements/ tools

- Two bowl seed cum fertilizer drill

Alternate farming systems

Marginal lands

- Silviculture: *Acacia tortilis*
- Land Capability Class III: Alley cropping (*Jatropha* spp + greengram)
- Land Capability Class IV: Silvipastoral system (*Prosopis cineraria* + *Cenchrus*)
- Horti – Pastoral system: Ber + *Cenchrus setigerus*
- Fodder/ green biomass: *Alianthus excelsa*, *Albizia lebbbeck*, *Dalbergia sissoo*, *Azadirachta indica*, *Prosopis cineraria*, *Dichrostachys*
- Fruit: Ber, date palm, jamun, fig, phalsa, koronda
- Medicinal/ Aromatic Plants: *Plantago ovata*, *Cassia angustifolia*, Safed musli, *Papaver somniferum*
- Vegetables: Cluster bean, cowpea, amaranthus, round melon, long melon
- Animal component: Male/ female cattle, female buffaloes, sheep, goat

Contingent planning

Good and normal rainfall

- Grow large areas under improved varieties of cereals, pulses and oilseeds during *kharif* on heavy soils, conserve soil moisture during *kharif* and take an early *rabi* crop of mustard or chickpea.

Normal onset followed by long gaps in rainfall

- Drought hardy crops with deep root system and low water requirement like sorghum, castor, pigeonpea and sesame should be preferred over maize.

Delayed onset of monsoon

- Grow early maturing pulses (greengram, blackgram), oilseeds (sesame) and fodder crops (sorghum + cowpea). Intercropping of maize + blackgram/ pigeonpea, groundnut + sesame is recommended.

Early withdrawal of monsoon

- Conserve the soil moisture received during last season and grow early *rabi* crops like rapeseed mustard, chickpea, safflower etc.

State	District	Region
Rajasthan	Jhalawar	High runoff and Low yield gap

Agro-geographic setting

- Climate: Hot moist semi arid
- Physiography: South East Rajasthan
- Soils: Deep clayey black soils, shallow black soils (Vertic Inceptisols – 100%)
- Annual rainfall: 1024 mm
- Potential evapotranspiration: 1557 mm
- Moisture availability period: 150-180/ 180-210 days

Soil and water conservation

- Broad bed furrow (BBF) for soybean
- Gabion structures in waterways
- Graded border strips
- Sowing across the slope
- Compartmental bunding
- Mulching

Crop management

- Varieties: JS-335, JS-71-05, MAUS-47, JS-93-05
- Seed rate: 75 kg/ha
- Planting Pattern: 30–45x5 cm
- Nutrient management: 20 kg N + 60 kg P₂O₅ + 20 kg K₂O+20kg S/ha
- Pest management: Effective insect pest control during 30 days of sowing could minimize losses to 10%

Some other important practices

- Seed inoculation with *Bradyrhizobium japonicum* @ 5 g/kg seed is economical
- Seed treatment with 2 g Thiram + 1 g Carbendazim per kg seed followed with *Bradyrhizobium japonicum* before sowing

Farm implements/ tools

- Two bowl seed cum fertilizer drill

Alternate farming systems

- Fodder/ green biomass: *Alianthus excelsa*, *Albizia lebbbeck*, *Dalbergia sissoo*, *Azadiracta indica*, *Prosopis cineraria*, *Dichrostachys*
- Fruit: Ber, date palm, jamun, fig, phalsa, koronda
- Medicinal/ Aromatic Plants: *Plantago ovata*, *Cassia angustifolia*, Safed musli, *Papaver somniferum*
- Vegetables: Clusterbean, cowpea, amaranthus, round melon, long melon
- Animal Component: Male/ female cattle, female buffaloes, sheep, goat

Contingent planning

Good and normal rainfall

- Grow large areas under improved varieties of cereals, pulses and oilseeds during *kharif* on heavy soils, conserve soil moisture during *kharif* and take an early *rabi* crop of rapeseed mustard or chickpea

Normal onset followed by long gaps in rainfall

- Drought hardy crops with deep root system and low water requirement like sorghum, castor, pigeonpea and sesame should be preferred over maize.

Delayed onset of monsoon

- Grow early maturing pulses (greengram, blackgram), oilseeds (sesame) and fodder crops (sorghum + cowpea). Intercropping of maize + blackgram/ pigeonpea, groundnut + sesame is recommended

Early withdrawal of monsoon

- Conserve the soil moisture received during last season and grow early *rabi* crops like rapeseed mustard, chickpea, safflower etc.,

Summary

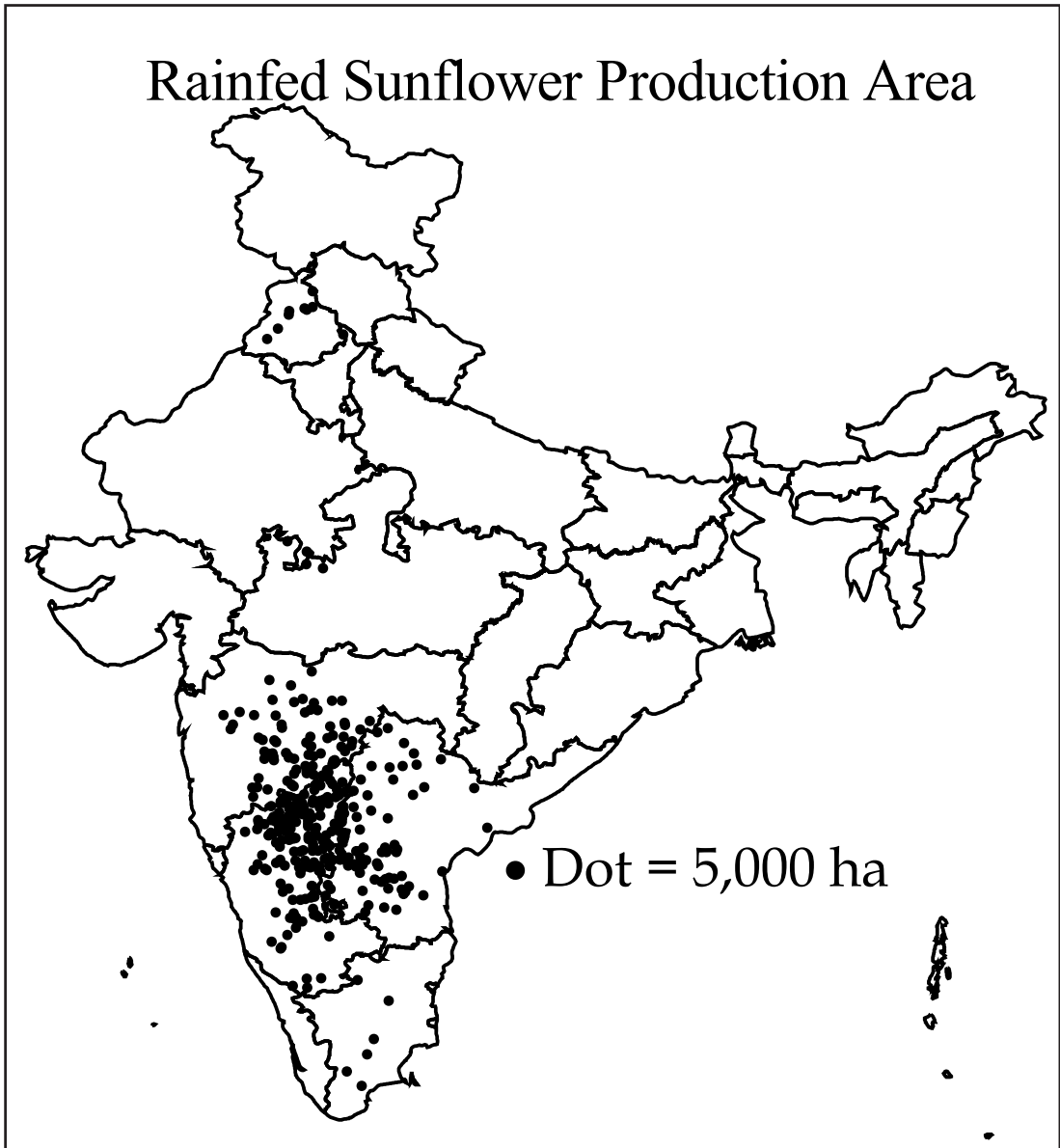
Soybean needs about 15 to 32°C temperature for germination, but for rapid growth the crop needs higher temperature. The crop requires about 60-65 cm annual rainfall. Drought at flowering or just before flowering results in flower and pod drops, while rains during maturity impairs the grain quality of soybean. The best soil type is sandy loam having good organic matter content. The water deficit is detrimental mostly at pod filling stage.

Two cropping seasons of soybean are *Kharif* and *rabi*. In case of *Kharif* season, most common time of sowing is onset of monsoon or last week of June to first week of July while spring sowing is done between 15th of February and 15th of March. Line sowing by seed drill is followed as it needs less seeds/ha, weeding and hoeing may be done conveniently. A 30-45 cm x 5 cm spacing is good for *Kharif* crop and 30-45 x 5 cm during spring season. Seed are placed at 2-3 cm in heavy soils and 3-4 cm light soils. Soybean grown for grain purpose needs about 20-30 kg seed/ha but for fodder crop needs about 75 kg/ha during *Kharif* season and 100-120 kg/ha during spring. Seeds are treated with rhizobium culture. Crop is supplied with 10-15% of total nitrogen requirement. Application of 25-30 cartloads of farm yard manure at the time of sowing proved better results. 20 kg/ha sulphur and also 25 kg Zinc sulphate and 10 kg Borax should be applied. At the time of sowing, one deep ploughing and two harrowings should be given to maintain optimum moisture at sowing.

Keep plot weed free upto 40 days by one or two hoeings and two weedings upto 40 days. Herbicides such as Tok -E- 25, 1.5 to 2 Kg/ha pre-emergence before sowing control the weeds. Herbicides: Fluchloralin @ 2 l/ha or Trifluralin @ 2.1 l/ha as Preplant Incorporator or Alachor @ 4 l/ha or Metolachlor @ 2 l/ha or Pendimetalin @ 3.33 l/ha or Clorzone @ 2 l/ha as Pre emergence followed by one dora after 20 days after sowing or Imazathapyr @ 1 l/ha or quizalofop ethyl @ 1 l/ha or Fenaxy prop P-ethyl 750 ml/ha or Chlorimuron ethyl @ 36 g/ha as Post emergence (15-20 days after sowing)

Intercropped or mixed with maize, sesame, pigeonpea, drilled paddy, sorghum, cotton and sugarcane. It can be rotated with wheat, potato, chickpea, tobacco etc. Crop is harvested at proper stage by usual method, threshing machine. Loss of green colour of pods, moisture content of seed 15% are the signs of maturity.

Prioritised cultural options				
State	District	Prioritised Options	Average Yield (kg/ha)	Expeceted Yield (kg/ha)
Madhya Pradesh	Guna	Adoption of improved varieties,	710	780 to 815
	Hoshangabad,	crop management technologies,	815	895 to 935
	Sagar,	emphasis on semi permanent		
	Seoni, Vidisha	soil conservation structures		
	Betul, Bhopal,	-do-	900	985 to 1030
	Dewas, Ratlam, Sehore			
	Raisen	Crop management strategies including pest and disease management. Utilization of surplus water for second crop to increase overall productivity	915	1010 to 1055
Maharashtra	Dhar, Mandasaur	Suitable drainage mechanisms to avoid water logging problem, long duration cultivars and suitable cropping management techniques	980	1080 to 1130
	Chindwara, Indore,	-do-	1050	1156 to 1210
	Ujjain			
	Narsinghpur	Crop management strategies including pest and disease management. Utilization of surplus water for second crop to increase overall productivity	1365	1390 to 1455
Rajasthan	Nagpur	Suitable drainage mechanisms	710	775 to 815
	Chittorgarh	to avoid water logging problem, long duration cultivars and suitable cropping management techniques	980	1079 to 1130
Uttar Pradesh	Jhalawar	-do-	1050	1155 to 1210
	Shajhapur	Adoption of improved varieties crop management strategies. <i>In situ</i> soil conservation measures	895	985 to 1030



SUNFLOWER BASED PRODUCTION SYSTEM

The cultivated sunflower (*Helianthus annus L.*) is a native of southern United States and Mexico, from where it was taken to Spain before the middle of the sixteenth century. In the nineteenth century, the cultivation of sunflower as an oil seed crop began in the Soviet Union and the majority of the present day varieties grown all-over the world trace back their origin to the USSR. The major sunflower-producing countries of the world are the Soviet Union, Argentina, Bulgaria, Pumania, Turkey and South America. Sunflower, as an oilseed crop, was introduced into India in 1969 and, according to the estimates of the trade and the Vanaspati Manufacturers Association, 3,88,000 ha of sunflower was grown in India during 1975-76. Sunflower is mainly grown for its oil. The oil is used for culinary purposes, in preparation of vanaspati and in the manufacture of soaps and cosmetics. It is especially recommended for heart patients. Its cake is rich in protein and is used as a cattle and poultry feed.

The production and protection technologies generated so far have helped a great deal in increasing area and production of sunflower in the country. It has also helped in reducing the import of edible oils thereby saving valuable foreign exchange. The farmers are finding the crop very profitable resulting in extension of the crop to non-traditional areas also.

Sunflower is grown in 1.63 mha in 224 districts out of which 1.25 mha is rainfed. About 85% of the rainfed area (0.9 mha) is in 11 districts.

Selection criteria	No. of districts	Area under Sunflower ('000 ha)	Area under Rainfed Sunflower ('000 ha)	Gross Cropped Area ('000 ha)	Yield (kg/ha)
States (13)	224	1630	1246	120243	492
Agro Eco Region**	179	1406	1075	97692	531
85% Rainfed Sunflower Area	11	1143	902	12067	441

** Arid, semiarid and dry sub humid

The trends in area and yield growth rates of eleven districts are given below:

Area	Yield	State	District
Increasing	Decreasing	Maharashtra	Nanded, Latur
		Ahmednagar	

The area growth rate is significantly rising for all districts.

The popular production systems prevailing in various AESRs are presented below.

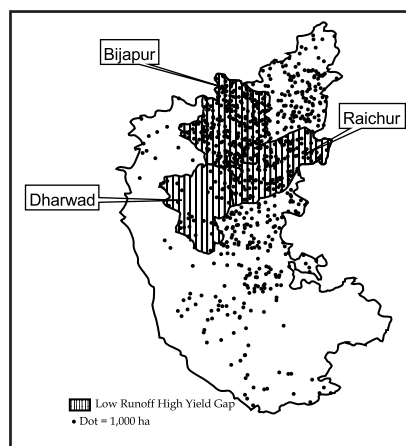
Agroecoregion	Production System
Hot semi-arid Deccan plateau	Sunflower-chickpea Sunflower-pigeonpea

The recommendations on this crop based production system are given below state and district-wise in alphabetical order for the regions with low (<12%), medium (12–25%) and high (>25%) runoff surplus index, and low (<33%), medium (33-66%), and high (>66%) yield gap from achievable yield (which is 70% of potential yield based normal rainfall, soil water holding capacity and water requirement) of sunflower crop are presented:

Karnataka

In Karnataka there are three districts viz., Bijapur, Dharwad and Raichur under low runoff and high yield gap region.

State	District	Region
Karnataka	Bijapur Dharwad Raichur	Low runoff and High yield gap



Agro-geographic setting

Bijapur

- Climate: Hot arid
- Physiography: North Karnataka plateau
- Soils: Deep loamy and clayey mixed red and black soils (Vertisols – 50%; Vertic Inceptisols – 50%)
- Annual rainfall: 573 mm
- Potential evapotranspiration: 1649 mm
- Moisture availability period: 60 – 120 days

Dharwad

- Climate: Hot dry sub humid
- Physiography: Western Karnataka plateau
- Soils: Shallow and medium loamy and clayey black soils, 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

Soil and water conservation

Bijapur

- Rubbles at 0.3 m vertical interval on contour key lines
- Compartmental 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, sissoo 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
- *In situ* conservation measures like compartmental bunding, ridges and furrows, contour cultivation and fall ploughing helped to conserve more moisture in deep black soils

Dharwad

- Rubbles at 0.3 m vertical interval on contour key lines
- Compartmental 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, sissoo 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 should be on farmer oriented soil conservation measures like *insitu* conservation measures
- Plant sunhemp in *rabi* areas
- Rubbles at 0.3 m vertical interval on contour key lines
- Compartmental 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, sissoo 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

Crop management

Bijapur, Dharwad, Raichur

- Hybrids : MSFH-8, BSH-1, KBSH-1, MSFH-17, Jwalamukhi, Sungene-85, PAC-36, PAC-1091, DSH-1, MLSFH-47, KBSH-41, KBSH-42, DSH-95, DSH-4, DSH-15, KBSH-1
- Varieties : Morden, TNAUSUF-7
- Seed rate: 8 kg/ha
- Planting pattern: 60x30 cm
- Nutrient management: 50 kg N + 25 kg P₂O₅/ha.

Some other important practices:

- Sowing in second week of August
- Seed treatment with Thiram/ Captan-3 g and *Azotobacter*-25 g

Suitable cropping systems

Bijapur, Dharwad, Raichur

- Greengram-sunflower
- Cucumber-sunflower

Soil	Efficient intercropping	Row ratio
Alfisols	Groundnut + sunflower	4:2, 3:1
	Pigeonpea + sunflower	1:2, 1:1
	Finger millet + sunflower	4:2
Vertisols	Pigeonpea + sunflower	3:1

Farm implements/ tools

Bijapur, Dharwad, Raichur

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

Alternate farming systems

Bijapur, 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: *Casuarina*, *Dalbergia sissoo*, *Hardwickia binata*, *Acacia nilotica*, *Prosopis cineraria*
 - Marginal land: *Dalbergia sissoo*, Neem, *Acacia nilotica*, Subabul
- Alley cropping: Subabul/ casuarina + *kharif* crops
- Agro horti system: Ber (Umran) + curry leaf, ber (Umran) – safflower + chickpea, ber/ custard apple/ pomegranate/ amla + *kharif* (spreading) crops
- Horticulture: Mango plants in levelled portion of zingg conservation terrace
- Fodder/green biomass: *Dalbergia sissoo*, *Gliricidia*, *Albizia 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: Female and male cattle, female buffaloes, goat, sheep, poultry

Contingent Planning

Bijapur, 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 compartmental bunds having 1% slope, scooping where the land slope is 1 to 2%, 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.
- 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 Hirsutam. 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.
- 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 of *rabi* sorghum till October 15th with 50% recommended level of fertilizer.
- Follow mixed 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.

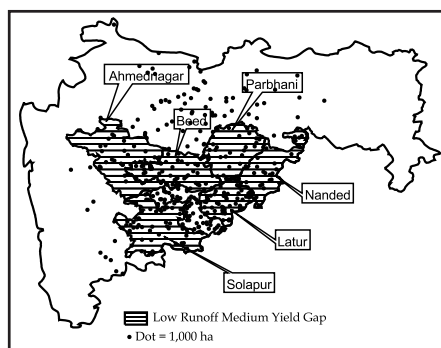
Early stoppage of rains towards the end of season:

- Thin out the population by blading every third row or alternate row within 40 days of sowing.
- 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%.
- Use surface mulches of mixed trash or farm waste wherever possible where farm waste is not available, use a blade to form a thin layer of soil mulch to avoid cracks.

Maharashtra

In Maharashtra there are six districts viz., Ahmednagar, Beed, Latur, Nanded, Parbhani and Solapur under low runoff and medium yield gap region.

State	District	Region
Maharashtra	Ahmednagar	Low runoff and
	Beed	Medium yield gap
	Latur	
	Nanded	
	Parbhani	
	Solapur	



Agro-geographic setting

Ahmednagar

- Climate: Hot dry semi arid
- Physiography: Western Maharashtra Plateau
- Soils: Shallow and medium loamy black soils, deep clayey black soils (Vertic Inceptisols – 60%; Vertisols – 40%)
- Annual rainfall: 676 mm
- Potential evapotranspiration: 1605 mm
- Moisture availability period: 90 – 120 days

Beed

- Climate: Hot dry semi arid
- Physiography: Western Maharashtra Plateau
- Soils: Shallow and medium loamy black soils, deep clayey black soils (Vertic Inceptisols – 100%)
- Annual rainfall: 685 mm

- Potential evapotranspiration: 1606 mm
- Moisture availability period: 90 – 120 days

Latur

- Climate: Hot moist semi arid
- Physiography: Central Maharashtra Plateau
- Soils: Shallow and medium loamy black soils, medium and deep clayey black soils, (Vertic Inceptisols 100%)
- Annual rainfall: 891 mm
- Potential evapotranspiration: 1861 mm
- Moisture availability period: 120 –150 days

Nanded

- Climate: Hot semi arid
- Physiography: Central Maharashtra Plateau
- Soils: Shallow and medium loamy, medium and deep clayey black soils (Vertic Inceptisols – 60%; Vertisols – 25%)
- 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, 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

Solapur

- Climate: Hot moist semi arid
- Physiography: South Westren Maharashtra Plateau
- Soils: Shallow and medium loamy black soils, deep clayey black soils (Vertic Inceptisols – 60%; Orthids – 40%)
- Annual Rainfall: 743 mm
- Potential evapotranspiration: 1801 mm
- Moisture availability period: 90 – 120 days

Soil and water conservation

Ahmednagar, Nanded, Solapur

- Contour bunds
- Graded bunds for high rainfall patches
- Suitable surface drainage measures in high rainfall and deep black soils to avoid water logging
- Supplemental irrigation in high rainfall areas with harvested water during dry spells
- *In situ* conservation measures like mulching, conservation furrows, deep tillage

- Compartmental bunding, ridges and furrows prior to sowing
- Marvel-8 grass on bunds for protection of bunds
- Contour live bunds of Marvel-8 of *Leucaena*
- *Leucaena* lopping mulch at 3.5 t/ha

Beed, Latur, Parbhani

- Compartmental 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* lopping mulch at 3.5 t/ha

Crop management

Ahmednagar, Beed, Latur, Nanded, Solapur

- Varieties: EC- 68414, Morden, SS-56, KBSH-1, JwalaMukhi, BAC-36, BAC-1091, TNAUSUF-7, Surya, SS-56, LS-11
- Hybrids: MSFH-8, BSH-1, KBSH-1, MSFH-17, LSH-1, LSH-3, PKVSH-27, Sungene-85, PAC-36, PAC-1091, MLSFH-47, KBSH-11
- Seed rate: 10 kg/ha
- Planting pattern: 45x30 cm for heavy soils and 45x22.5 cm for light soils
- Nutrient management: 50 kg N + 25 kg P₂O₅/ha
- Pest management:
 - Endosulfan (35 EC) 700 ml in 500 l of water per ha for caterpillars and borers
 - Mancozeb 1250 g in 500 l water/ha for anthracnose.
 - Weeding (one) before 30 days, followed by 2 hoeings at 30 and 50 days after sowing

Some other important practices

- Seed treatment with Thiram 3 g + Metalaxyl 6 g and *Azotobacter* 25 g for one kg of seed.
- Protective irrigation at flowering and seed filling
- Hand pollination by rubbing palm gently on flower

Parbhani

- Varieties: EC-68414, JwalaMukhi, BAC-36, BAC-1091, TNAUSUF-7, Surya, SS-56 and LS-11
- Hybrids: MSFH-8, BSH-1, PKVSH-32, KBSH-1, MSFH-17, LSH-1, PKVSH-9, LSH-3, PKVSH-27, Sungene-85, PAC-36, PAC-1091 and MLSFH-47
- Seed rate: 10 kg/ha
- Planting pattern: 45x30 cm for heavy soils and 45x22.5 cm for light soils
- Nutrient management: 50 kg N + 25 kg P₂O₅/ha.
- Pest management Endosulfan (35 EC) 700 ml in 500 l of water/ ha for caterpillars and borers
- Mancozeb 1250 g in 500 l water/ha for anthracnose.

Suitable cropping systems

Ahmednagar, Beed, Latur, Nanded, Solapur

- Sunflower + pigeonpea (2:1) for soils having more than 45 cm depth.
- Sunflower – chickpea
- Pigeonpea + sunflower (2:2)
- Soybean + sunflower (2:1)
- Groundnut + sunflower (6:2)

Parbhani

- Soybean – sunflower
- Pigeonpea + sunflower (2:2)
- Soybean + sunflower (2:1)
- Groundnut + sunflower (6:2)

Farm implements/ tools

Ahmednagar, Beed, Latur, Nanded, Solapur

- 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 former: Bund formers were tested and found suitable for compartmental bunding. Rs.1050/-
- Baliram plough: Identified for moisture conservation practices like ridges and furrows and compartmental 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/-

Parbhani

- Bullock drawn two-row seed cum fertilizer drill
- Bullock drawn Shivaji multipurpose farming machine

Alternate farming systems

Ahmednagar, Beed, Latur, Nanded, Solapur

- Agro-horti system - Ber (5x5 m) + mothbean (8 lines) (30x10 cm)
- Silvipasture: *Leucaena* + Marvel – 8 grass
- 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*, *Albizzia lebbeck*, *Dalbergia sissoo*, Neem, *Prosopis cineraria*
- Fruit: Ber, date palm, jamun, fig, phalsa, karonda
- Medicinal/ Aromatic plants: *Plantago ovata*, *Cassia angustifolia*, Safed musli, *Papaver somniferum*
- Vegetables: Clusterbean, cowpea, amaranthus, round melon
- Animal component: Female buffalo/ sheep, goat

Parbhani

- Agri-horticultural system - Ber (5x5 m) + mothbean (8 lines) (30x10 cm)
- Silvipasture: *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*, *Albizzia lebbeck*, *Dalbergia sissoo*, *Azadirachta indica*, *Prosopis cineraria*
- Fruit: Ber, date palm, jamun, fig, phalsa, karonda
- 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

Ahmednagar, Beed, Latur, Nanded, Solapur

- Lands < 22.5 cm depth of soil should be cultivated with agroforestry and dryland horticulture including ber, custard apple, amla, wood apple, jambhul etc.
- Silvipastoral system of subabul + Marvel-8 with cutting of the alternate trees at 7th year onwards for fuel is also recommended.

Contingent Planning

Ahmednagar, Beed, Latur, Nanded, Solapur, 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

Summary

Sunflower belongs to the family Compositae and the genus *Helianthus*. A single stem terminating in a capitulum characterizes the cultivated genotypes. Sunflower is protandrous, in which the male and female elements mature at different times. There appears to be a time-lag of 18-24 hours in the maturity of the male and female elements. So it is essentially a cross-pollinated plant, besides showing varying degrees of self-incompatibility.

Sunflower is a day neutral plant and can be grown successfully in different seasons under varying conditions of day length, provided the temperature is favourable. Sunflower, basically a temperature plant, can also be grown commercially in tropical or sub-tropical conditions. It grows best with clear sky and occasionally rain shower during early stages. This crop requires a cool climate during germination and seedling growth and warm non-cloudy weather and high temperature during flowering to maturity. Sunflower can tolerate temperature range of 8 to 30° C but the temperature below 16° C and above 40° C reduces yield and oil content. High temperature affects pollination and fertilization, thus care should be taken to adjust the sowing date in such a way that flowering does not coincide with high temperature. The optimum temperature for best performance under controlled conditions is 27-28° C. Sunflower can be planted successfully when soil temperature exceeds 10° C, though germination begins at 3-5° C. Young plants (1 or 2 pairs of leaves) can withstand frost to -6° C. However, plants are frost sensitive from 6-8 leaf stage until flowering finishes. Late frost does not destroy the whole plant but destroys the fruiting head, leading to increased branching, resulting in small heads with many empty fruits. During flowering temperature should be between 18-20° C. Good yields are obtained where the ruling temperature is 18-22° C showing that generally speaking the crop needs a warm climate. Average minimum temperature below 17° C between flowering and maturity is necessary to ensure best oil quality. The crop is grown from 45° S to 55° N but greater production is between 20-50° S. The crop can be cultivated upto an altitude of 2500 m but highest yield of oil is obtained below 1500 m. Sunflower cannot tolerate frost and requires a frost free period of 120 days. It is resistant to drought but requires continuous availability of soil moisture for the best performance.

Sunflower can thrive on a wide range of soils such as sandy loam, black soil and alluvial soil, but it performs better on sandy loam soil than on clay soil under similar management. However, good drainage is more important than soil type. Thus, fertile, well drained, medium textured soils having heavy water holding capacity are best suited for the cultivation of sunflower. Sunflower is highly susceptible to water logging. Avoid cultivation of sunflower on soils affected by salts and with poor drainage. The optimum pH requirement is 6.0 to 8.5. It performs well in deep, neutral and well-drained light soils as well as in heavy soils. The optimum pH of the soils for this crop is 6.5-8.5.

Sunflower is one crop in the case of which, the season of planting are not the limiting factors. Three to four ploughings and diskings are sufficient for preparing the land. Soil should be moist at least 10 cm deep before sowing and this condition necessitates good soaking rains or irrigation before sowing. Seed rate is 8-10 kg of well-filled seeds/ ha. For controlling seed-borne fungal diseases, seed treatment with either Brassicol or Captan @ 3 g/ kg of seed is recommended. The pre-soaking of seed for 12-24 hours ensures a rapid and high percentage of germination, an early emergence and establishment of the crop. The seed is drilled at a depth of 5 cm by adopting a spacing of 45 cm between rows and 30 cm between plants in the row.

Sunflower requires a fine seedbed, free of weeds and clods, for proper germination and good crop stand. To bury the residues of previous crop, ploughing with disc harrow followed by 2-3 cultivations and plankings may be required. Fields vacated by potato may not require much seedbed preparation. However, adequate soil moisture is essential for getting good germination.

Spring season is the best for getting higher and stable seed yield sunflower. Sunflower being a cross pollinated crop depends on honeybees for pollination and seed setting. Availability of honeybees is abundant during spring season. Planting during spring should be made after the soil temperature exceeds 10° C at 10 cm depth at 8 a.m. Earlier planting at lower temperature increases time of flowering without much earliness. Best results are obtained when crop is sown in the first fortnight of January which produces higher seed yield than later planting. By sowing short duration hybrids like GKSFH-2002, PSFH-67 and NSFH-592, this can be extended upto second fortnight of January. Besides low yields, the late sowing may also face early monsoon rain at harvesting and threshing causing difficulty in its management.

Use 5 kg seed per ha for hybrids to achieve the required plant stand. Low seed rate recommendation for hybrids is mainly because of smaller seed size and wider spacing. Seed should be treated with Brassicol or Thiram @ 2 g per kg of seed to control seed and soil borne fungal disease. A spacing of 60x30cm for hybrids has been found to be an optimum. This spacing result in better development of head, more seed filling and less stem breakage.

Rain after sowing, results in crust formation, which hinders the proper emergence of seedlings. Thus it may be necessary to break the crust, which can be done with harrowing. Harrow as soon as possible after the crust has formed and if possible, before seedlings have emerged

Promising varieties and cropping systems for other sunflower growing rainfed regions are given below

Andhra Pradesh	Hybrids	APSH-11, MSFH-8, KBSH-1, MSFH-17, Jwalamukhi, Sungene-85, PAC-36, PAC-1091, MLSFH-47
	Varieties	Morden, TNAUSUF-7,
Tamil Nadu	Hybrids	MSFH-8, KBSH-1, MSFH-17, Jwalamukhi, PAC-36, Sungene-85, PAC-1091, TCSH-1, MLFSH-47
	Varieties	Morden, TNAUSUF-7, CO-1, CO-2
Punjab	Hybrids	KBSH-1, PSFH-67, Jwalamukhi, Sungene-85, PAC-36
	Varieties	Morden
Haryana	Hybrids	KBSH-1, Jwalamukhi, Sungene-85, PAC-36
	Varieties	Morden
Gujarat	Hybrids	KBSH-1, Jwalamukhi, Sungene-85, PAC-36, PAC-1091, MLSFH-47
	Varieties	Morden, TNAUSUF-7, GAUSUF-15
Other states	Hybrids	KBSH-1, Jwalamukhi, Sungene-85, PAC-36, PAC-1091
	Varieties	Morden, TNAUSUF-7,

Suitable cropping systems

State	Soil type	Efficient intercropping	Row ratio
Andhra Pradesh	Alfisols	Groundnut + sunflower	4:2
	Alfisols	Pigeonpea + sunflower	1:2
	Alfisols	Castor + sunflower	1:2
Tamil Nadu	Alfisols	Groundnut + sunflower	3:1
	Alfisols	Castor + sunflower	1:1
Gujarat	Vertisols	Groundnut + sunflower	1:1
Non-traditional areas	Inceptisols	Blackgram/ Greengram + sunflower	4:2/ 3:1

Double cropping

For areas receiving more than 750 mm RF, the soil moisture storage capacity with more than 20 cm of available water

Vertisols

- Blackgram - Sunflower
- Greengram - Sunflower
- Pearl millet - Sunflower
- Cowpea - *Kharif* Sunflower
- *Rabi* Sorghum - *kharif* Sunflower

Andhra Pradesh, Karnataka, Tamil Nadu:

- Groundnut - Sunflower

Sowing time

Sowing time should be decided in such a way that the flowering and seed filling stages of the crop do not coincide with continuous rainy period or high temperatures above 38°C.

Kharif

Light soil areas	:	second fortnight of June to mid July
Heavy soils areas	:	second fortnight of August
<i>Rabi</i> (Rainfed)	:	September of first fortnight of October
<i>Rabi</i> (Irrigated)	:	November
Summer (Irrigated)	:	second fortnight of January to February first week
Spring/ <i>Zaid</i>	:	15 th January to end of February

Ultimate seed yields in rainfed *rabi* crop depends on the extent of residual moisture available at planting time and the subsequent rains in the later part of September and early October. Therefore, prefer early planting and avoid moisture stress at critical stages of crop growth.

General practices in all Rainfed Sunflower growing areas

Pre soaking and seed treatment

For quick germination and better stand establishment in Dryland conditions, soak the seed in fresh water (1:1 W/v) for about 14 hours and shade dry. Seed should be treated with Thiram or Captan @ 2-3 g/kg of seed to protect from seed borne diseases. Seed treatment with Metalaxyl @ 6 g/kg can protect the crop against downy mildew disease.

Thinning

Though sunflower has wide plasticity for variation in plant population, it is highly susceptible to competition from more than one plant per hill. Maintenance of optimum population by judicious thinning at 10-15 days after germination to maintain single healthy plant per hill is essential for obtaining higher yields, besides easy interculture and crop management.

Fertilizer management

The crop performs best when both organic and inorganic fertilizers are applied to it. The fertilizer Nitrogen: Phosphorus: Potash (NPK) schedules recommended in the case of rainfed are 20:30:20 (NPK) of per hectare.

Field studies have shown that hybrid sunflower responds well to nitrogen application. Increase in nitrogen results in lower seed and oil yield. Application of phosphatic fertilizers @ 30 kg P₂O₅/ha increase sunflower yield. Sunflower responds to K₂O application only on soils deficient in available potassium. Regarding application method, drilling the fertilizers besides the seed row has been found to be more beneficial for getting higher seed yield. Application of fertilizers below the seed was found to be injurious to germinating seeds and reduced seed emergence count and seed yield. Entire dose of N, P₂O₅ and K₂O should be applied at the same time of sowing. Prefer single super phosphate for P₂O₅ application as it also contains sulphur to which sunflower responds favourably. If single super phosphate is not available, apply gypsum @ 25-30 kg/ha at sowing time. A supplementary dose of nitrogen @ 25-30 kg/ha may be top dressed a month after sowing sunflower if the crop exhibits symptoms of nitrogen deficiency.

Mechanical methods such as hoeing at 3-4 weeks after sowing followed by earthing up before flowering has been found to be effective in checking weeds. Use of tractor drawn implements before the crop attains 60-70 cm height has also been found effective. For better efficiency of manual weeding, an improved 3 tine wheel hand-hoe could also be used. Removal of weeds through mechanical/manual means means quite effective but expensive. Moreover, often timely labour is not available. The studies initiated to find effective herbicides for weed control in sunflower, revealed that pendimethalin (STOMP @ 2.51/ha) as pre-emergence application gave effective weed kill.

Important diseases of sunflower and their management

Disease/ causal organism	Management practice/ Control measures
Alternaria blight and leaf spot (<i>Alternaria helianthi</i>)	<ul style="list-style-type: none"> - Treat the seed with Captan/ Thiram @2.5 g or Carbendazim 1.0 g/kg seed. - Early planting (<i>kharif</i>) escape from the disease. - Spray the crop with Mancozeb (0.3%), 3-4 times at 15 days interval or Rovral (0.05%) 2 sprays.
Rust (<i>Puccinia helianthi</i>)	<ul style="list-style-type: none"> - Removal and destruction of crop residues, volunteer sunflower plants reduces the disease severity. - Foliar spray with Mancozeb/ Zineb 0.2% or Calixin 0.1% at 30 days interval in effective in control of the disease.
Downy mildew (<i>Plasmopara halstedii</i>)	<ul style="list-style-type: none"> - In endemic areas avoid continuous sunflower growing, follow 3-4 yearly crop rotation - Early sowing, shallow planting escapes from the disease. - Clear cultivation, rouging of infected plants reduces the disease incidence. - Treat the seed with Apron 35 SD @ 6 g/kg of seed and combined with foliar spray of Metalaxyl/ Ridomyl) 25 WP gives best control. - In disease prone areas use resistant hybrids such as LSH-1 and LSH-3.
Sclerotium wilt(<i>Sclerotium rolfsii</i>)	<ul style="list-style-type: none"> - Seed dressing with Captan/ Carboxin 3-6 g/kg of seed. - Adding of soil amendments and antagonistic fungi such as <i>Trichoderma harzianum</i> incorporated into soil reduces the disease incidence. - Crop rotation of 3-4 years to be adopted. - Avoid moisture stress/ water logging conditions in the field.
Charcoal rot (<i>Macrophomina phaseolina</i>)	<ul style="list-style-type: none"> - Seed treatment with Thiram 3 to 4 g/seed to be followed - Avoid moisture stress during high summer. - Deep ploughing in summer and crop rotation are effective in checking the disease.
Head rot(<i>Rhizopus arrhizus</i>)	<ul style="list-style-type: none"> - Spray with Copper oxychloride @ 0.4% or Mancozeb 0.3% combined with Endosulfan (0.05%) at 50% flowering stage.
Sunflower Necrosis Disease (new viral disease)	<ul style="list-style-type: none"> - Follow clean cultivation and remove weeds specially <i>Parathenium</i>, <i>Commelina</i> etc. both from inside and neighbouring fields. - Seed treatment with Imidacloprid @5 g/kg of seed protect the crop from insect vectors during early stages of the crops. - Give prophylactic sprays 2-4 times at 15-35 days interval with Imidacloprid (0.01%) or Oxydemeton Methyl (0.2%) to check the insect vector.

Important insect pests of sunflower and their management

Insect pests	Pest management practices
Seedling Pest	
Cut worm (<i>Agrotis sp.</i>)	Sow the seeds on slopes of ridges (6-8 cm height)Apply Chlorpyrifos (20EC) @ 3.75 l/ha to soil with irrigation water.
Grasshoppers (<i>Attractomorpha crenulata</i>)	Follow clean cultivation by keeping bunds and fields weed free.Apply Methyl parathion 2% dust @ 25 kg/ha
Sucking pests	
Leaf hopper (<i>Amrasca biguttula biguttula</i>)	White fly (<i>Bemesia tabaci</i>)Thrips (<i>Scirtothrips dorsalis and Thrips sp.</i>) Seed treatment with Imidacloprid 70 WS @ 5 g/kg of seedApply Imidacloprid 200 SL @ 0.1 ml/l of water at 15-20 days interval orSpray with Phosphamidon (0.03%) or Dimethoate (0.03%) or Monocrotophos (0.05%)

Foliage pests	
Bihar hairy caterpillar (<i>Spilosoma oblique</i>)	Collect and destroy egg masses and early stage larvae of <i>S.Litura</i> and <i>S.obliqua</i> on damaged leaves. Spray neem kernel extract (NSKE) 5% or Endosulfan (0.07%) or
Tobacco caterpillar (<i>Spodoptera litura</i>)	Dichlorvos (0.05%) or Fenitrothion (0.05%) in 500 – 700 l of spray solution/ ha or
Green semilooper (<i>Thysanoplusia orichalcea</i> and <i>Trichoplusia ni</i>)	dust Methyl parathion (2%) @ 25 kg/ha
Capitulum borer	
(<i>Helicoverpa armigera</i>)	Spray <i>Bacillus thuringiensis</i> @ 2 l/ha or <i>Helicoverpa</i> NPV @ 250 LE/ha or
Endosulfan	(0.07%) or Monocrotophos (0.05%) in 500-700 l of spray solution/ ha

Precautions for spraying insecticides:

- Spraying during flowering should be avoided to protect the pollinators.
- Spray in the afternoon when pollinators are less so that there is a time gap till morning or mid day when their activity is more.
- Spray only when pest incidence is observed in abundance.
- Spray on calm day to avoid drift.
- Precautionary measures are advisable if pest outbreak is observed every year.

The sunflower crop matures in 90-100 days. The crop is ready for harvesting when the back of flower heads turn lemon yellow or yellowish brown near the stalk and the discs start drying. At this stage the seeds give a blackish look and are fully ripe. The shading of disc-flower residues from undamaged heads also indicates physiological maturity. Promptly harvesting seed after physiological maturity has many advantages; seed is least exposed to bird and rodent attack; the crop cycle is shorter resulting in more time to prepare for the next crop; reduces harvest seed losses; provides high quality seed and reduces exposures to bad weather. The harvested heads are mildly dried and threshed by beating or trampling with tractors or sunflower threshers. The sunflower threshers are more efficient and economical. After threshing the produce should be thoroughly dried before storing otherwise in storage it gets affected by fungus and decomposes. The crop has to be harvested when the lower side of the head turns yellow and some of the bracts dry up. The mature heads are cut with a sickle and are dried by exposing the upper side with seeds to the sun. The well-dried heads are beaten with sticks to separate the seeds. The cleaned seed is dried well and stored in gunny bags. The sunflower crop gives a grain yield of 300-500 kg/ha under rainfed conditions and 800-1200 kg/ha when grown under irrigation.

Researches show that sunflower depresses the growth and productivity of succeeding crops. The reason postulated is the allelochemicals being secreted by sunflower crop. Decomposing residues of sunflower could also bring about allelopathic effects. Phytotoxic compounds released into the soil rhizosphere have been observed to cause varying degree of allelopathy/autotoxicity in crop. Field studies conducted in the department of Agronomy, Punjab Agricultural University, Ludhiana on the allelopathic effect of spring sunflower on succeeding *Kharif* crops revealed that maize, sorghum, cowpea, pearl millet, pigeonpea, greengram and sesame suffered 41.7, 36.7, 27.6, 28.8, 23.0, 10.8 and 9% reduction in yield, respectively, as compared to these when grown after wheat. Studies in allelopathic effects of different plant parts of sunflower indicated that sunflower roots reduced pigeonpea, cotton and greengram yields the most followed by roots plus shoots treatment. Sunflower shoots did not have any harmful effect on growth of these crops. Bioassay studies involving use of aqueous sunflower extract, decomposing plant residue and soil from area in proximity of sunflower crop revealed inhibition of germination and growth of cotton, pigeonpea, sunflower and greengram. These studies further showed that effect of leaf extract/residue was more than roots. The allelopathic effect of sunflower plant residue persisted upto 24 days after incorporation and beyond this period the effect was rather meagre. Chromatographic and physico-chemical analysis of allelochemicals in sunflower parts showed the presence of chlorogenic and isochlorogenic acids in both stems and leaves besides these some unidentified phytotoxins were also observed. The concentration of these was more in leaves than in stems. Further studies revealed that total phenolics were more in leaves followed by in roots and shoots. Sunflower raised under moisture stress conditions had higher phenolics as compared to the raised without any moisture stress.

Important hints to obtain higher yields

- Continuous cropping of sunflower year after year in the same field should be avoided.
- Take up sunflower plantings in such a way that flowering does not coincide with heavy rainfall period in coastal belt and avoid cultivation of sunflower in *kharif*.
- Avoid low lying areas for sunflower cultivation.
- Always use certified seed obtained from authorized seed producing/ supplying agencies.
- Always treat the seeds with recommended pesticides before sowing.
- Always maintain optimum plant stand recommended for particular region. Maintain one seedling per hill by thinning at 15-18 days after sowing.
- Use presoaked seeds wherever soil moisture in the seed zone is insufficient at planting time.
- Incorporate FYM or compost 2 to 3 weeks before sowing.
- Keep sunflower field weed free through recommended cultural/ chemical weed control practices during first 45 days of crop period.
- In the event of moisture stress, irrigate the crop at the critical stages i.e. bud, flowering and seed development stages.
- Spray Boron @ 0.2% at ray floret opening stage.
- Do not spray insecticides during the flowering period.
- Wherever bee activity is low, resort to hand pollination.
- Protect the predators such as coccinellids and chrysoperia.

Prioritised cultural options				
State	District	Prioritised Options	Average Yield (kg/ha)	Expeceted Yield (kg/ha)
Karnataka	Bijapur	Improved management technologies	330	390 to 410
	Dharwad, Raichur	-do-	380	455 to 475
Maharashtra	Ahmednagar, Beed, Solapur	<i>Insitu</i> conservation technologies along with improved crop management strategies	515	590 to 620
	Latur, Nanded	Crop management strategies and timely availability of inputs	570	655 to 685
	Parbhani	-do-	455	520 to 550

Cultivars Released during 1996 – 2002

The information on varieties/ hybrids released during 1996-2002 from the Annual Report(s), Department of Agricultural Research and Education, Ministry of Agriculture, Government of India, Indian Council of Agriculture Research, New Delhi, Oilseeds Situation: A Statistical Compendium – 2002, by T. Damodaram and D.M. Hegde. (2002), Directorate of Oilseeds Research, Hyderabad and from others is summarized below. The cultivars suit for rainfed and partially irrigated conditions. The details follow.

Cultivar	Recommended region	Salient features (Year of release)
Castor		
DCH 177 (Hybrid)	Andhra Pradesh, Tamil Nadu, Karnataka, Rajasthan	1.50 t/ha; 49% oil (1998), resistant to wilt (1998-99)
PCH 1	Andhra Pradesh	1.6-1.9 t/ha, early, dwarf (2000–2001)
DCH-32 (Deepthi)	All parts of India	1.80 t/ha; 49% oil (1997)
GCH-5 (SHB-145)	All parts of India	1.74 t/ha; 50% oil (1997)
GCH-6 ((JHB-665)	Gujarat, Rajasthan, Maharashtra	1.39 t/ha; 48% oil (1999)
TNAUCH-1	Tamil Nadu	1.40 t/ha; 52% oil (1999)
DCS-9 (Jyothi)/ REC-9	Rainfed areas of Andhra Pradesh, Tamil Nadu and Karnataka	1.02 t/ha; 49% oil (1995)
Kranti (PCS-4)	Andhra Pradesh	1.20 t/ha; 48% oil (1999)
48-1	Karnataka	1.80 t/ha; 51% oil (1998)
Rapeseed Mustard		
VSL	Uttar Pradesh, Madhya Pradesh, Chattisgarh, Rajasthan	Early maturing than Varuna(1998-99)
RN 393	Punjab, Haryana, parts of Uttar Pradesh, Rajasthan	(1998-99)
Ragini (Yellow sarson)	Eastern Uttar Pradesh, Bihar and Jharkhand	1.6 t/ha, bold seed and high oil (2000 – 2001)
Pusa Agrani	Bihar, Orissa, Jharkahand	1.0 t/ha (2000 – 2001)
JMT-689	Punjab	(1997)
TS-36	Assam	1.20 t/ha; 42.43% oil (1998)
TS-38	Assam	42.43% oil (1998)
Aravali (RN 393)	Rajasthan, Haryana, Punjab	1.46 t/ha; 41% oil (2001)
Basanrti (RK 8501)	Uttar Pradesh	1.49 t/ha; 41% oil (2001)
CS-52 (DIRA-343)	Uttar Pradesh, Haryana, Rajasthan	1.12 t/ha; 41% oil (1999)
Jawahar-1 (JMWR-93-39)	Madhya Pradesh	2.00-2.10 t/ha; 41% oil (1999)
Kiran (PBC 922)	Western Uttar Pradesh, Northern Rajasthan, Punjab, Haryana, Delhi	2.20-2.50 t/ha; 40% oil (1997)
NDRE (Narendra Ageti Rai)	Uttar Pradesh	2.00 t/ha (2001)
PBR-91	Punjab	1.60-1.80 t/ha; 40% oil (1996)

Cultivar	Recommended region	Salient features (Year of release)
PBR-97	Punjab	1.90-2.20 t/ha; 42% oil (1997)
PCR-7 (Rajat)	Gujarat, Maharashtra, Rajasthan, Haryana	1.90 t/ha; 39% oil (1997)
SEJ-2 (Agrani)	Delhi	1.40 t/ha; 40% oil (1997)
VSL-5 (Jagannath)	Uttar Pradesh, Rajasthan	1.80 t/ha; 41% oil (1999)
Urvashi (RK 9501)	Uttar Pradesh	1.70 t/ha; 39% oil (2000)
Gulechin (KOD-100)	Kashmir	1.00 t/ha; 38-40% oil (1996)
Jhumka (YSBNC-1)	West Bengal, Assam, Bihar, Orissa	1.20-1.30 t/ha; 46% oil (1998)
Narendra Sarson-2 (NDYS-2)	Uttar Pradesh	1.20-1.70 t/ha; 43% oil (1997)
Rajendra Sarson-1	Bihar	1.50-1.70 t/ha; 42% oil (1996)
Karan Tara (RTM 314)	All parts of India	1.05 t/ha (2001)
GSL-2	Punjab, Rajasthan, Haryana	1.90-2.00 t/ha; 45% oil (1996)
Hyola 04-1	Punjab, Rajasthan, Haryana	1.20 t/ha; 42% oil (1997)
PGSH-51	Punjab, Rajasthan, Haryana	1.95 t/ha; 44% oil (1996)
Kiran (PBC 9221) oil	Punjab, Haryana, Rajasthan,	Low fertility areas; 2.36 t/ha; 40% Delhi, Uttar Pradesh (1998)
Toria		
PBT-37	Punjab	1.35 t/ha; 43% oil (1996)
ORT (M) 2-4 Parbati	Orissa	1.30-1.50 t/ha (2001)
African Sarson		
PC-5 oil	Punjab, Haryana, Rajasthan,	Low fertility areas; 1.99 t/ha; 38% Delhi, Uttar Pradesh (1996)
Safflower		
DSH-129	All parts of India	1.99 t/ha; 31% oil (1997)
MKH-11	All parts of India	1.90 t/ha; 31% oil (1997)
A-2	Karnataka	1.00-1.20 t/ha; 31% oil (1997)
JSI-73	Madhya Pradesh	1.45 t/ha; 31% oil (1999)
NARI 6	Maharashtra	1.02 t/ha; 30% oil (2001)
Soybean		
Ahilya 1 (NRC 2)	Uttarnchal, Madhya Pradesh, Chattisgarh, Bundelkhand region of Uttar Pradesh, Rajasthan, Gujarat and Northern Orissa	Determinate, good germinability, resistant to <i>Rhizoctonia</i> , pod blight, green mosaic virus, bacterial blight and tolerant to <i>Cercospora</i> leaf spot and anthracnose (1997-98)
Ahilya 2 (NRC 2)	Madhya Pradesh, Bundelkhand region of Uttar Pradesh, Rajasthan, Gujarat and Northern Orissa	Determinate, resistant to bacterial pustules, <i>Myrothecium</i> leaf spot, bacterial blight, yellow mosaic virus, aerial blight and tolerant <i>Rhizoctania</i> , to defoliators, stem fly and girdle beetle (1997-98)

Cultivar	Recommended region	Salient features (Year of release)
Ahilya 3 (NRC 7)	Madhya Pradesh, Chattisgarh	Determinate, high oil content, resistant to pod-shattering, shows resistance to bacterial blight, green mosaic virus, bacterial pustules, phyllody, soybean mosaic, <i>Myrothecium</i> and <i>Cercospora</i> leaf spots and tolerance to stem fly, girdle beetle, green and grey semiloopers, leaf miner and defoliators (1997-98)
Pooja (MAUS 2)	Maharashtra	Semi-determinate, resistant to pod-shattering, resistant to green mosaic, bacterial pustules, rust and leaf spots and moderately resistant to leaf miner, stem fly and blue beetle (1997-98)
MACS 450 and tolerant to stem –fly and defoliators	Andhra Pradesh, Karnataka,	Resistant to yellow mosaic virus Tamil Nadu, parts of Maharashtra (1998-99)
Indira Soya – 9	Madhya Pradesh	2.30 t/ha (2000)
JS-90-41	Madhya Pradesh	2.50-3.00 t/ha (1999)
KB-79 (SNEHA)	Karnataka	1.70 t/ha (1997)
MAUS-32 (Prasad)	Maharashtra	3.00-3.50 t/ha; 19% oil (2000)
MAUS-47 (Parbhani Sona)	Maharashtra, Madhya Pradesh, Rajasthan	2.50-3.00 t/ha; 20% oil (2000)
NRC-4 (Ahilya)	Madhya Pradesh, Maharashtra, Rajasthan, Bundelkhand of Uttar Pradesh	3.50-4.00 t/ha; 21% oil (2000)
PK-1042	Northern plain zone	3.30 t/ha (1997)
Pant Soya - 1092	Uttar Pradesh	3.50 t/ha (2000)
SL-295	Punjab	(1997)
VL-Soya 47	Hills of Uttaranchal	2.50-2.70 t/ha; 23% oil (2000)
VSL-497	Northern Hill Zone	2.80 t/ha; 23% oil (1999)
Sunflower		
LS 11	Maharashtra, Andhra Pradesh	Early maturing (1998 – 1999)
DSH-1	Karnataka	1.60 t/ha (1998)
MLSFH-47 (AH-II-34) and Tamil Nadu	Maharashtra, Karnataka, Andhra Pradesh, Orissa, Madhya Pradesh, Gujarat	2.20-2.50 t/ha; 35% oil (2000)
PAC-1091	All parts of India	1.68 t/ha; 38% oil (1998)
PAC-36	All parts of India	1.69 t/ha; 38% oil (1998)
PAC-47		(1997)
PKVSH 27	Vidharba region of Maharashtra	1.30-1.60 t/ha; 39% oil (1996)
SUNGENE-85	All parts of India	1.00-1.50 t/ha; 40-43% oil (1998)
TCSH-1	Tamil Nadu	1.85 t/ha; 39% oil (2000)
Jwalamukhi (PSCL05015)	All parts of India	1.60 t/ha; 40-42% oil (1996)

Annexure-II

Popular and Botanical Names of Some Crops

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

Rapeseed (Sarson)	<i>Brassica campestris</i> L. var. Sarson Prain
Raya (Mustard)	<i>Brassica juncea</i> (L.) Czern. & Coss
Redgram (Pigeonpea, Arhar, Tur)	<i>Cajanus cajan</i> (L.) Millsp
Rice (Paddy)	<i>Oryza sativa</i> L.
Rozella (Mesta)	<i>Hibiscus sabdariffa</i> L.
Safflower	<i>Carthamus tinctorius</i> L.
Sarson (Rapeseed)	<i>Brassica campestris</i> L. var. Sarson Prain
Sesame (Sesamum, Gingelly, Til)	<i>Sesamum indicum</i> L.
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.
<i>Triticale</i>	<i>Triticale officinale</i>
Urd (Blackgram)	<i>Vigna mungo</i> (L.) Hepper

Generic and Brand Names of some Heribicides/Weedicides

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

ANILOPHOS 30% EC: Aerozin (Agr. Evo), Sumo (Dupont), Glyphotox (AIMCO), Ricil (De'Nocil), Anilostar (Shaw Wallace), 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), Milchlor (Montari), Wid Kil (Sudarshan Chemicals), Aimchlor (AMICO), Nirmool (Lupin), Starchlor (Shaw Wallace), Dhanuchlor (Dhanuka), Speclor (Southern Pesticides), Hiltaklor (Hindustan Insecticides), Trapp (Searle India), Delchlor (Coromandel Indag), Bilchlor (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-Poulneq)

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)

Generic and Brand Names of Some 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), Killex 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), Agroduran (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-Zeneca), 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), Hiltchoate (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 Inida), Bilfen (Bayer), Starfen (Shaw Wallance), Fen-Fen (Parry Chemicals), Topfen (Thakar Chemicals), Tagfen (Tropical Agro), Trump Card (Dhanuka), Hilfen (Hindustan Insecticides), Fencron (Novartis), Sumitox (AIMCO), Fenkill (United Phosphorous), Lufen (Lupin), Starfen (Shaw Wallance), Agrofen (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 (Rhouné – Poulneq), Tempo (Agr Evo)

FORMOTHION 25%: Anthio (Novartis)

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

MALATHION 50 EC: Dhanuka Malathion (Dhanuka), Cythion (Cyanamid Agro), Sulmation (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), Sofos (Sudarshan Chemicals), Monostar (ShawWallance), Specron (Southern Pesticides), Hycrophos (Hyderabad Chemicals), Topcil (Thakar Chemicals), Monocin (IOCL), Monochem (New Chemi), Parryphos (EID Parry), Milphos (Montari), Monodhan (Dhanuka), Phoskill (United Phosphorous), Lumphos (Lupin), Kadett (Pesticides India), Agromonark (Gujarat Agro), Moncar (Bhaskar Agro), Azodrin (Cyanamid Inida), Hilcron (Hindustan Insecticides), Macrofos (Tropical Agro), Croton (Searle India), Balwan (Rallis), Monophos (Parry Chemicals), Monocron (NFCL), Corophos (Coromandel Indag), Bilphos (Bayer), Monosect (Agr 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), Lumphate (Lupin), Agro-Phorate (Gujarat Agro), Helmet (Tropical Agro Chemicals), Warrant (Searle India), Hilphorate (Hindustan Insecticides), Grenades

PHOSALONE 35% EC & 4% Dust: Zolone (Rhouné-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), Rilón (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 (Rhouné-Poulneq)

Generic and Brand Names of Some 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)

Index

Andhra Pradesh

Guntur	Castor (8,10,12)
Hyderabad	Castor (9,10,11,12,13)
Mahaboobnagar	Castor (9,10,11,12,13)
Nalgonda	Castor (9,10,11,12,13)
Prakasam	Castor (9,10,12)
Ranga Reddy	Castor (9,10,11,12,13)
Warangal	Castor (10,11,12,13)

Chattisgarh

Bastar	Rapeseed Mustard (33,34)
Surguja	Rapeseed Mustard (33,34,35)

Karnataka

Bijapur	Safflower (75,76,77,78), Sunflower (130,131,132,133)
Dharwad	Safflower (79,80,81), Sunflower (130,131,132,133)
Gulbarga	Safflower (79,80,81)
Raichur	Safflower (75,76,77,78), Sunflower (130,131,132,133)

Madhya Pradesh

Betul	Soybean (112,116,117,118,119)
Bhopal	Soybean (113,116,117,118,119)
Bhind	Rapeseed Mustard (36,37,38)
Chindwara	Soybean (113,116,117,118,119)
Dewas	Soybean (113,116,117,118,119)
Dhar	Soybean (108,109,110,111)
Guna	Soybean (113,116,117,118,119)
Gwalior	Rapeseed Mustard (40,41,42)
Hoshangabad	Soybean (113,116,117,118,119)
Indore	Soybean (114,116,117,118,119)
Mandla	Rapeseed Mustard (43,44)
Mandsaur	Soybean (109,110,111)
Morena	Rapeseed Mustard (40,41,42)
Narsinghpur	Soybean (114,116,117,118,119)
Raisen	Soybean (114,116,117,118,119)
Ratlam	Soybean (114,116,117,118,119)
Sagar	Soybean (114,116,117,118,119)
Sehore	Soybean (115,116,117,118,119)
Seoni	Soybean (115,116,117,118,119)
Shahadol	Rapeseed Mustard (36,37,38,39)
Shajhapur	Soybean (115,116,117,118,119)
Shivpuri	Rapeseed Mustard (40,41,42)
Ujjain	Soybean (115,116,117,118,119)

Maharashtra

Ahmednagar	Safflower (82,83,84,85), Sunflower (134,135,136,137,138,139)
Aurangabad	Safflower (86,87,88,89,90,91)
Beed	Safflower (92,93,94,95,96,97), Sunflower (134,136,137,138,139)
Buldana	Safflower (87,88,89,90)
Jalna	Safflower (92,93,94,95,96,97)
Latur	Sunflower (135,136,137,138,139)
Nagpur	Soybean (120,121,122)
Nanded	Sunflower (135,136,137,138,139)
Osmanabad	Safflower (93,94,95,96,97)

Parbhani	Safflower (87,88,89,90,91), Sunflower (135,136,137,138,139)
Pune	Safflower (87,88,89,90,91)
Solapur	Safflower (93,94,95,96,97), Sunflower (135,136,137,138,139)

Orissa

Balasure	Rapeseed Mustard (45,46,47,48)
Cuttack	Rapeseed Mustard (49,50,51,52)
Dhenkanal	Rapeseed Mustard (53,54,55)
Kalahandi	Castor (14,15,16,17), Rapeseed Mustard (49,50,51,52)
Koraput	Castor (15,16,17), Rapeseed Mustard (49,50,51,52)
Phulbani	Rapeseed Mustard (45,46,47,48)

Rajasthan

Alwar	Rapeseed Mustard (56,58,59,60,61)
Bharatpur	Rapeseed Mustard (56,58,59,60)
Bhundi	Rapeseed Mustard (57,58,59,60,61)
Chittorgarh	Soybean (123,124)
Dholpur	Rapeseed Mustard (57,58,59,60,61)
Jaipur	Rapeseed Mustard (57,58,59,60,61)
Jhalawar	Soybean (125)
Kota	Rapeseed Mustard (61,62)
Sawaimadhapur	Rapeseed Mustard (57,58,59,60,61)
Tonk	Rapeseed Mustard (57,58,59,60,61)

Tamil Nadu

Dharmapuri	Castor (18,19,20)
Salem	Castor (19,20)

Uttar Pradesh

Agra	Rapeseed Mustard (63,64,65,66)
Etawah	Rapeseed Mustard (63,64,65,66)
Hamirpur	Castor (21)
Kanpur (Rural)	Rapeseed Mustard (63,65)
Kanpur (Urban)	Rapeseed Mustard (63,65)
Mathura	Rapeseed Mustard (64,65,66)

In parantheses are page numbers

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