

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

**Districtwise
Promising Technologies
for Rainfed Chickpea based
Production System in India**



**All India Coordinated Research Project for Dryland Agriculture
Central Research Institute for Dryland Agriculture
Hyderabad
2005**

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About this compendium

Crop based recommendations are available from several sources. 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 chickpea were identified. Their agro geographic setting, soil and water conservation, crop management including nutrient management, pest management, suitable cropping systems, alternate farming systems and contingency plans were described in the background of crop yield gap and runoff of a district.

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Central Research Institute for Dryland Agriculture**

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Agroindustries

• Implements • Seeds
• Fertilizers • Pesticides

State Department(s) of Agriculture

• Andhra Pradesh • Bihar
• Chattisgarh • Gujarat • Karnataka
• Madhya Pradesh • Maharashtra
• Rajasthan • Uttar Pradesh

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CHICKPEA BASED PRODUCTION SYSTEM

Chickpea, Bengal gram (Bengalgram) or Gram (*Cicer arietinum* L.) is a premier crop of India grown in diverse agro-climatic conditions under various cropping systems. Botanical and archaeological evidences suggest that chickpea was first domesticated in the middle east as early as 5450 BC and subsequently spread to India, Europe, Australia and other regions of the World. Van der Massen (1987) suggested Southeastern part of Turkey adjoining Syria as possible center of origin. In India the records of chickpea cultivation date back to 2000 BC at Atranjikhhera (UP) and 300-100 BC at Nevasa (Maharashtra). In India, it is mainly grown now in the states of Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, etc. It is used in many forms as dal, chhole, sweets and many attractive dishes. Snacks are prepared from its flour. Its leaves contain malic and citric acid, which are very useful for stomach ailments and it is best blood purifier. Nutritionally it is very rich as it contains about 18-22 percent protein, 62 per cent carbohydrate, and good amount of fat; besides it is a rich source of Ca, Fe and vitamin C (in green stage) and vitamin B₁. Its feed and straw are highly rich in nutrients and are mostly used as productive ration.

Being a leguminous and hardy crop chickpea does very well under dry tracts, which receive an annual rainfall of 60-100 cm. It prefers fairly cold weather but frost is deadly harmful, especially at flowering and grain formation stages. Hailstorm at maturity causes great damage to the crop.

Chickpea is grown on a variety of soils ranging from a very light sandy loam to heavy textured clay. In Maharashtra chickpea is grown on black cotton soils. The best type of soil is clay loam with an efficient drainage and free from soluble salts preferably having neutral pH.

Chickpea is grown in 6.8 m ha in 346 districts out of which 5.3 m ha is rainfed. About 85% of the rainfed area (3.4 m ha) is in 85 districts.

Selection Criteria	No. of Districts	Area under Pigeonpea ('000 ha)	Area under Rainfed Pigeonpea ('000 ha)	Gross Cropped Area ('000 ha)	Yield (kg/ha)
Rainfed states (13)	346	6821	5304	167868	809
AESR 3-13	261	5186	3990	131273	739
Cumulative 85% Rainfed chickpea area	85	4384	3381	53331	757

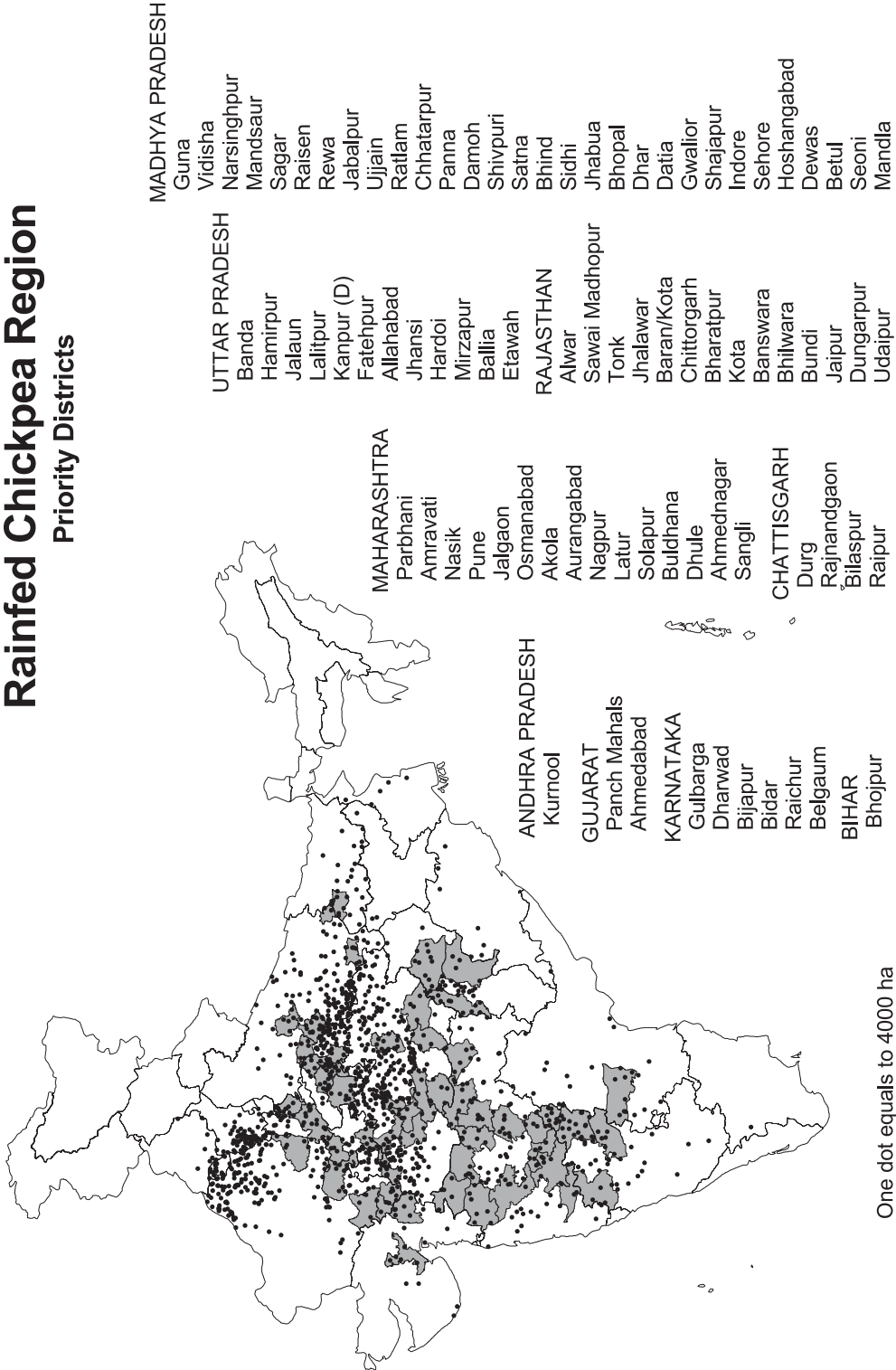
The data base is 1966-94 in 16 states - Andhra Pradesh, Bihar, Jharkhand, Chhattisgarh, Orissa, Madhya Pradesh, Maharastra, Gujarat, Punjab, Rajasthan, Uttaranchal, Uttar Praddesh, Karnataka, Tamilnadu and West Bengal covering arid, semi-arid, and dry sub-humid regions. Arid deserts were not considered at present.

Trends in the area and yield growth rates for different districts are given below

Area	Yield	State	District
Stagnant	Increasing	Madhya Pradesh	Ratlam, Datia, Dewas, Seoni
		Maharashtra	Parbhani
		Rajasthan	Chittorgarh, Banswara, Bhilwara, Bundi, Dungarpur
Stagnant	Stagnant	Gujarat	Ahmedabad
		Karnataka	Belgaum
		Madhya Pradesh	Mandasur, Raisen, Chattarpur, Bilaspur, Jhabua, Siddhi, Dhar, Indore, Mandla
		Maharashtra	Osmanabad, Solapur
		Rajasthan	Alwar, Sawai Madhopur, Tonk, Kota, Udaipur
Decreasing	Stagnant	Uttar Pradesh	Mirzapur
		Madhya Pradesh	Bhind, Gwalior
		Rajasthan	Bharatpur, Jaipur
		Uttar Pradesh	Banda, Jalaun, Fatehpur, Allahabad, Hardoi, Balia, Etawah

Rainfed Chickpea Region

Priority Districts



Increasing	Increasing	Andhra Pradesh Madhya Pradesh Maharashtra	Kurnool Narasinghpur, Durg, Ujjain, Damoh, Shivpuri, Satna, Sehore, Shajapur, Hoshangabad, Raipur Pune, Amravati, Aurangabad, Akola, Jalgaon, Nagpur, Dhule, Buldhana
Stagnant	Decreasing	Gujarat Karnataka	Panchmahal & Bidar
Increasing	Stagnant	Karnataka Madhya Pradesh Maharashtra Rajasthan Uttar Pradesh	Gulbarga, Dharwad, Bijapur, Raichur Guna, Vidisha, Sagar, Rewa, Panna Nasik, Sangli, Ahmednagar Jhalawar Jhansi
Decreasing	Increasing	Madhya Pradesh	Jabalpur, Betul
Decreasing	Decreasing	Uttar Pradesh	Hamirpur

Popular chickpea involved production systems in farmers' fields in various agro-ecoregions follows:

Agroeco region	Production System
Hot arid eco sub region of Karnataka plateau	Fingermillet/ groundnut/ pearl millet - chickpea Safflower/ <i>rabi</i> sorghum + chickpea
Hot semi arid eco region of Northern plains	Pearlmillet/ maize/ groundnut/ fallow - chickpea, chickpea + barley
Semi-arid eco region of central highlands (Malwa), Gujarat plain and Kathiawar peninsula semi arid eco-region	Wheat + chickpea Maize/ sorghum - chickpea
Hot semi arid eco region of Deccan plateau	Pearlmillet/ sunflower - chickpea
Hot semi-arid eco region of Eastern Ghats, Tamilnadu uplands and Deccan (Karnataka) plateau	Fingermillet/ groundnut/ pearl millet - chickpea Chickpea + safflower
Hot (dry) subhumid eco region of northern plains	Maize/ rice - chickpea
Hot subhumid (dry) eco region of central highlands (Malwa and Bundelkhand)	Rice/ sorghum/ blackgram/ greengram - chickpea, chickpea + linseed, wheat + chickpea, chickpea + mustard
Hot moist/ dry subhumid region of moderately to gently sloping Chattisgarh/ Mahanadi basin	Fallow/ rice/ sesame - chickpea
Hot subhumid eco region of eastern plateau (Chota Nagpur) and eastern ghats	Rice - chickpea
Hot (moist) subhumid eco-region of eastern plain	Rice - chickpea

From the cluster analysis, six farming associations were identified. The percent cropped area in gross cropped area along with animal population is presented.

Districts	Percent Cropped Area	Animals (No./km ²)
Farming System 1		
Chhattarpur, Gwalior, Datia	Chickpea (21.8), Sorghum (11.97)	Goat (40.15)
Bhind, Jhabua, Bhundi,	Maize (9.02), Wheat (8.11)	Male Cattle (31.46)
Chittoorgarh, Jhalawar	Rapeseed mustard (7.22)	Female Cattle (26.18)
Jhansi, Lalitpur, Jalaun	Soybean (6.37), Pearl millet (2.81)	Female Buffalo (18.52)
Hamirpur, Banda, Mirzapur	Rice (2.74), Linseed (2.25) Greengram (1.28), Barley (1.26) Safflower(0.48), Cotton (0.34) Potato(0.26), Sunflower(0.23)	Sheep (9.5)
Farming System 2		
Shivpuri, Panch Mahals	Maize (22.62), Chickpea (14.07)	Goat (78.91)
Banswara, Bhilwara	Rice (12.51), Sorghum (6.5)	Male Cattle (50.2)

Dungarpur, Udaipur	Pearlmillet(6.02), Wheat (3.69)	Female Buffalo (33.6)
Etawah, Fatehpur	Rapeseed mustard (3.42)	Female Cattle (30.96)
Allahabad, Ballia	Barley (3.09), Potato (2.48)	Sheep (21.41)
Hardoi, Kanpur (Dehat)	Greengram (1.08), Linseed (0.87)	Male Buffalo (6.69)
Bhojpur	Soyabean (0.85), Cotton (0.73)	
	Safflower (0.44), Onion (0.25)	
	Sugarcane (0.17), Sunflower (0.16)	
Farming System 3		
Durg, Raipur, Bilaspur	Rice (40.98), Wheat (15.16)	Male Cattle (32.19)
Jabalpur, Seoni, Mandla	Chickpea (11.95), Linseed (5.72)	Female Cattle (25.54)
Damoh, Panna, Rewa	Soybean (4.79), Maize (2.53)	Goat (19.2)
Sidhi, Satna, Rajnandgaon	Sorghum (2.3), Rapeseed	Female Buffalo (6.39)
	mustard (1.26), Barley (0.96)	Male Buffalo (5.77)
	Greengram (0.42), Safflower (0.24)	Sheep (2.34)
	Potato (0.15)	
Farming System 4		
Narsinghpur, Sagar	Soybean (37.68), Chickpea (14.32)	Male Cattle (22.58)
Guna, Indore, Ratlam	Sorghum (11.06), Wheat (10.98)	Goat (19.21)
Ujjain, Mandasaur, Dewas	Maize (5.51), Cotton (2.46)	Female Cattle (17.58)
Dhar, Jhabua, Sehore	Linseed (1.66), Rice (1.65)	Female Buffalo (11.34)
Raisen, Vidisha, Betul	Greengram (0.8), Rapeseed	Sheep (1.82)
Shajapur, Nagpur, Kota	mustard (0.68), Safflower (0.27)	
Bhopal	Potato (0.26), Sunflower (0.24)	
	Pearlmillet (0.16), Onion (0.11)	
Farming System 5		
Nasik, Alwar, Bharatpur	Pearlmillet (41.2), Rapeseed	Goat (50.77)
Jaipur, Sawai Madhopur	mustard (25.89), Chickpea (10.33)	Female Buffalo (31.01)
	Sorghum (6.72), Wheat (1.56)	Sheep (18.39)
	Maize (1.36), Rice (1.23)	Female Cattle (15.92)
	Greengram (1.1), Onion (0.95)	Male Cattle (12.12)
	Sugarcane (0.88), Barley (0.38)	Male Buffalo (0.07)
	Safflower (0.25)	
Farming System 6		
Kurnool, Dharwad,	Sorghum (32.66), Cotton (11.48)	Goat (30.75)
Belgaum, Bijapur, Bidar,	Pearlmillet (8.95), Sunflower (5.95)	Male Cattle (19.51)
Raichur, Gulbarga, Dhule,	Greengram (4.26), Chickpea (3.98)	Sheep (16.95)
Jalgaon, Ahmednagar, Pune	Safflower (3.15), Wheat (2.69)	Female Cattle (16.01)
Sangli, Sholapur,	Rice (2.06), Sugarcane (1.76),	Female Buffalo (12.38)
Aurangabad, Parbhani,	Maize (1.02)	
Osmanabad, Buldhana,	Rapeseed mustard (0.92), Soybean	
Akola, Amravati,	(0.86), Linseed (0.5)	
Ahmedabad, Tonk, Latur	Onion (0.47), Potato (0.11)	

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

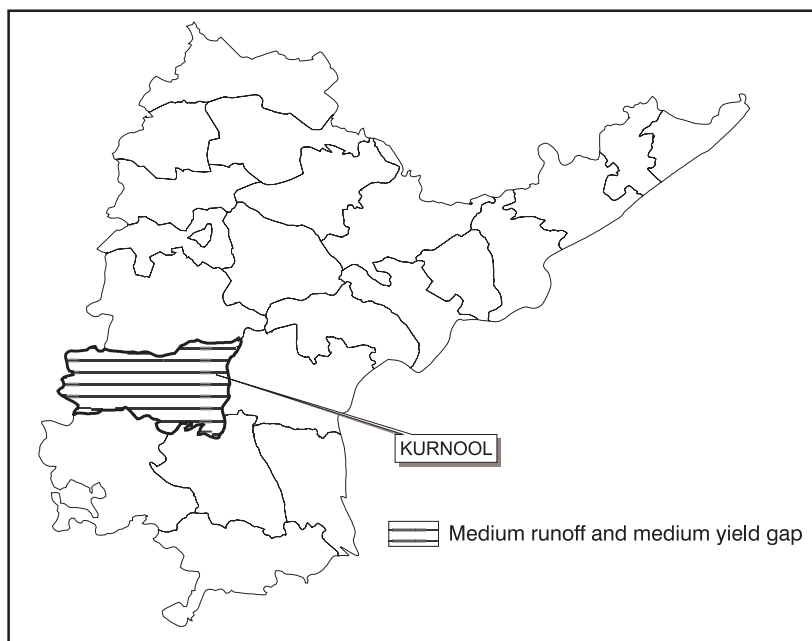
conservation and water harvesting; Drainage, *in situ* conservation and water harvesting, for low, medium and high surplus index regions, respectively.

The productivity (average yield 1990-91 to 1994-95) and annual rainfall (mean of past 30 years) were used for yield gap analysis, which is 0.7 of achievable yield based on water requirement satisfaction index. The yield gap was grouped as low (< 33%), Medium (33-66 %) and high (>66%). The possible options are non monetary inputs and improved varieties; non monetary inputs, fertilizer management and improved varieties; improved varieties, fertilizer management, plant protection measures, non monetary inputs or shifting alternate land uses, for low, medium and high yield gaps, respectively.

The available recommendations from network of research of National Agricultural Research System (NARS) were linked to the matrix of yield gap and surplus index. Recommendations are given for crop based production system, state-wise and group (s) of districts. These consist of integrated soil conservation and management, crop management (varieties, seed rate, planting pattern, integrated nutrient management, integrated pest management, suitable cropping systems, implements, suggested integrated farming systems, contingent planning, etc. A region was described in terms of agro-ecological setting, soils, climate, annual rainfall, PET and length of growing period. The identified priorities for increasing the productivity in short term are also included. The recommendations on this crop based production system are given state and district-wise in alphabetical order in following pages. The recommendations are given for 68 districts in 9 states. For remaining districts similar exercise could not be done due to insufficient data.

ANDHRA PRADESH

In Andhra Pradesh there is one district viz. Kurnool with medium runoff and medium yield gap.



District	Region
Kurnool	Medium runoff and medium yield gap

Agro-geographic setting

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

Soil and water conservation

- Contour bunds, graded bunds
- Contour bunding with a cross section of 0.63 m² and with horizontal spacing of 25 to 125 m is recommended for red soils. The other soil conservation measures like compartment bunds of 15 m length and 10 m width or conservation furrow at 3.6 m interval or intercropping mixed with pulses like cowpea and horsegram can be adopted.
- Integrated watershed management (manage in a < 10 ha watershed)
- Water harvesting inlined with Kadapa slabs to avoid seepage losses in dug out ponds

- Increasing catchment area and design of pond size for catchment size
- Interplot water harvesting of 1:1 cropped to uncropped area
- Use of life saving irrigation
- Indigenous water harvesting structures

Crop management

- **Varieties:** G11 & ICCV-2
- **Seed rate:** 75 kg/ha
- **Planting pattern:** 30 X 10 cm
- **Nutrient management:** 25 kg N + 50 kg P₂O₅ General recommendation
25 kg N + 20 kg P₂O₅+20 Kg S/ha Soil Test based recommendation.
- **Pest management:**
 - Pod borer management - NPV culture extract of 500 caterpillars in 500 l of water/ha or Methyl parathion (2% dust) 20 kg/ha or Quinalphos (25 Ec) one liter in 500 l of water/ha
- **Some other important practices:**
 - Seed inoculation with Rhizobium, seed priming

Suitable cropping systems

- Groundnut + chickpea

Farm implements/ tools

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

Alternate farming systems

- **Fodder/ green biomass:** *Dalbergia sissoo*, *Gliricidia*, *Albizia lebbeck*, *Cassia siamea*, *Azadirachta indica*, *Stylo*, Marvel-8 grass
- **Fruits:** Ber, custard apple, pomegranate, amla + *kharif* spreading crops
- **Medicinal and aromatic plants:** *Cassia angustifolia*, *Catharanthus roseus*, *Palmarosa*, *Vetiveria zizanioides*, Rose, Geranium

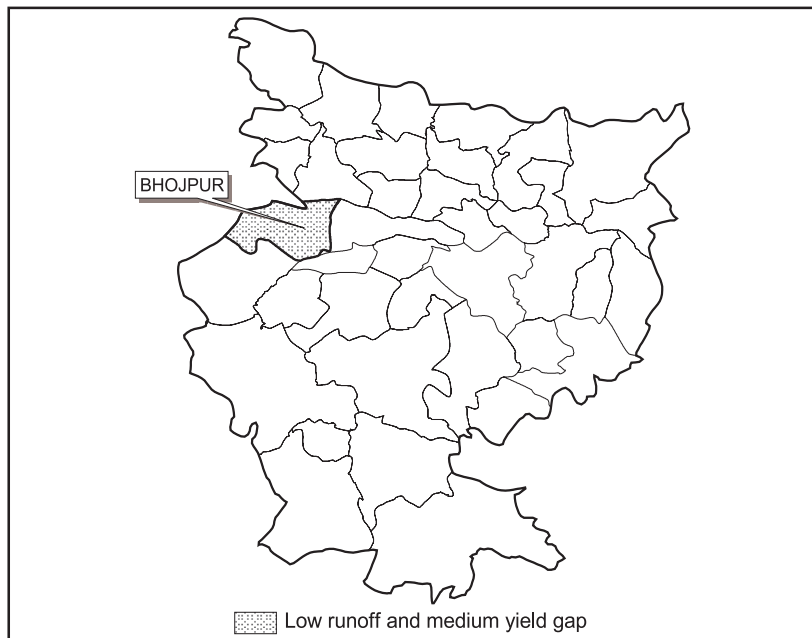
- **Vegetables:** Onion, brinjal, chillies, cowpea, cucumber, cluster bean, drumstick.
- **Mixed farming:** Crop + livestock (sheep @ 10/ha) system of farming will give 80% more income than crop system alone.

Contingent planning

- **Early onset of monsoon (last week of May or June)**
 - Sorghum (CSH-5), greengram, pigeonpea (Abhay), castor (GCH 4 or other hybrids, Kranthi), mesta (AMV -1)
- **Normal onset of monsoon (July)**
 - Groundnut, pigeonpea (TMV -2, J-11), castor (GCH 4 or other hybrids, Kranthi), mesta (AMV -1), setaria, pearl millet (MBH -110, MH-88), greengram
- **Late onset of monsoon (August)**
 - Sorghum, greengram (after August 15th), pearl millet (MBH -110), setaria, groundnut (TMV-2)
- **Very late onset of monsoon (September)**

BIHAR

In Bihar there is one district viz. Bhojpur with low runoff and medium yield gap.



District	Region
Bhojpur	Low runoff and medium yield gap

Agro-geographic setting

- **Climate:** Hot dry sub humid
- **Physiography:** West Bihar Plains
- **Soils:** Deep loamy alluvium - derived soils (Inceptisols - 80%; Ustalf/ Ustolls - 20%)
- **Annual rainfall:** 1079 mm
- **Potential evapotranspiration:** 1518 mm
- **Moisture availability period:** 150 - 180 days

Soil and water conservation

- Inter-plot water harvesting
- Raised and sunken bed system

Crop management

- **Varieties:** BG 256, RAU 52, KWR 108, BG 372, Radhey, BG 1003 (Kabuli)
- **Nutrient management:** 20 kg N + 40 kg P₂O₅ + 20 kg K₂O/ ha. Place fertilizer 10 - 15 cm deep in the seed furrows.

- **Pest management**

- Pod borers cause maximum damage. Maintain gram pod boere population through pheromone traps, spray 50 ml Dimecron or 1.5 l. Thiodon in 1000 l of water/ha at the time of flowering and at pod formation is recommended
- Spray 5 % neem seed kernal extract at flowering and repeat after 2 weeks.

Suitable cropping systems

- Rice - chickpea
- Chickpea + rapeseed mustard (4:1)
- Pearlmillet - chickpea
- Chickpea + barley (3:1)
- Chickpea + linseed (3:1)
- Sesame - chickpea
- Blackgram - chickpea

Farm implements/ tools

- Bullock drawn Malviya multi-farming machine: For field preparation, for seeding dryland crops and fertilizing through mechanical metering device, for intercultivation between two plant rows (particularly *Kharif* season crop). Rs.2350/-
- Dryland weeder (modified from of weeder supplied by T.A.U): For weed control between plant rows of rainfed crops. Rs. 70/-
- Malviaya seed-cum-fertilizer drill is also useful in this region.

Alternate farming systems

- **Fodder/ green biomass:** *Leucaena leucocephala*, *Azadirachta indica*, *Albizia lebbeck*, *Bauhinia purpurea*, *A. procera*, *B.monosperma*, *A.amara*, *D.sissoo*
- **Fruits:** Guava, amla, ber, mango, bael and jamun
- **Medicinal and aromatic plants:** *Papaver somniferum*, *Cymbopogan flexuosus*, *Psoralea*, *Palmarosa*, *Vetiveria zizanooides*
- **Vegetables:** Bottle gourd, brinjal, chillies, cluster bean, cowpea, round melon
- **Animal component:** Female cattle, male cattle, female buffaloes, sheep, goats, poultry

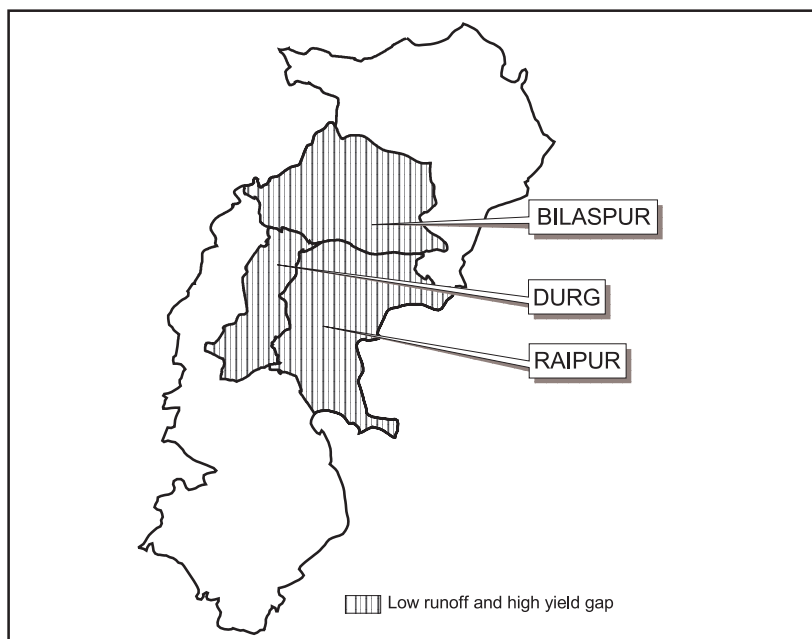
Contingent planning

- **Normal season**
 - **Kharif**
 - Rice (NDR-97, NDR-118, Govind and Vandana)
 - Maize (Ganga safed 2, Kanchan and Jaunpuri)
 - Pearlmillet (BJ 104, Pusa 23 and Pusa 322)
 - Blackgram (T.9, Pant U-19, Pant U -35, Uttara)
 - Greengram (Jyoti Jagriti, Janpriya, Pant moong-12 and Narendra moong-1, Pant mung 5)
 - Sesame (T4, T12 and Gujrat Til-1)
 - Pigeonpea (Bahar, NA-1 and Malyiya arhar 13)

- **Rabi**
 - Lentil (Pant L-406, Pant L-639, L 4076 and K 75, sheri)
 - Wheat (HUW-533, K-8027 and C-306)
 - Barley (DL3, Jyoti and K 125)
 - Rapeseed mustard (Varuna, Vardhan, Sanjukta and Kranthi)
 - Linseed (Garima and Neelam)
 - Chickpea (Pusa 256 Awarodhi and kwr 108)
- **Normal onset of monsoon followed by long gaps in rainfall**
 - In the case of very early break in monsoon i.e. 7-10 days after seeding and if seedlings are killed resow with the same variety.
 - Gap filling/ transplanting in case of cereals like upland rice and pearl millet may be done if drought occurs about a month after seeding and is followed by showers. Follow this by light top dressing i.e. 10-15 kg/ha. For this purpose community nurseries or emergency nurseries should be kept ready.
- **Delayed onset of monsoon**
 - If monsoon sets in as late as the last week of July, short duration upland rice such as NDR-97 and Vandana are recommended on medium and low lands. Uplands should be considered for pigeonpea-based intercrop. If rains are delayed beyond the period but start somewhere in the first to second week of August and growing season is reduced to 60-70 days, then the cultivation of hybrid pearl millet (BJ560, BJ.104), blackgram (T9), greengram (samrat, Jagriti, Jyoti) should be taken up. Pulse based intercropping is also recommended. Yet another alternative could be to harvest a fodder of sorghum, pearl millet, maize or mixture of either of cowpea, blackgram, greengram and one of the above fodder crops. Winter crops like rapeseed mustard, barley, lentil, linseed and chickpea will follow these crops.
- **Early stoppage of rains towards the end of season**
 - Normal growing of short duration *kharif* crops such as upland rice (NDR-97 or Vandana), blackgram (T.9) and sesame (T.13) may be taken. Sorghum, maize, pearl millet and cowpea for fodder could be harvested. If the rain stops very early, i.e. by the end of August or first week of September, only fodder crops and grain legumes could be harvested. Later on as a mid-season correction sunflower could be planted as it could be sown any time in the year.
- **In extreme drought conditions**
 - Only short duration crops like grain legumes (blackgram and greengram) should be grown
 - Among cereals, pearl millet (BJ 104) gave a fair performance
 - Rice crop, if already sown is not likely to succeed, may be ploughed under to conserve the moisture in the soil. This may permit growing of lentil, chickpea, rapeseed mustard or barley during *rabi*
 - Late season drought coinciding with reproductive phase of upland rice is frequently experienced (3/7 years). If period of drought approaches 8-10 days, 25% yield could be compensated by one life saving irrigation (5 cm depth)

CHHATTISGARH

In Chhattisgarh there are three districts viz. Bilaspur, Durg and Raipur with low runoff and high yield gap.



District	Region
Bilaspur Durg Raipur	Low runoff and high yield gap

Agro-geographic setting

Bilaspur

- **Climate:** Hot moist/ dry sub humid
- **Physiography:** Dhandakaranya (Eastern plateau)
- **Soils:** Deep loamy to clayey red and yellow soils (Ustolls - 100%)
- **Annual rainfall:** 1327 mm
- **Potential evapotranspiration:** 1475 mm
- **Moisture availability period:** 150 - 180 days

Durg

- **Climate:** Hot moist/ dry sub humid
- **Physiography:** Dhandakaranya (Eastern plateau)
- **Soils:** Deep loamy to clayey red and yellow soils (Alfisols - 60%; Ustalf/ Ustolls - 40%)
- **Annual rainfall:** 1277 mm

- **Potential evapotranspiration:** 1651 mm
- **Moisture availability period:** 150 - 180 days

Raipur

- **Climate:** Hot moist/ dry sub humid
- **Physiography:** Chattisgarh/ Mahanadi Basin
- **Soils:** Deep loamy to clayey red and yellow soils (Ustalf/ Ustolls - 50%; Alfisols - 25%; Vertisols - 15%)
- **Annual rainfall:** 1388 mm
- **Potential evapotranspiration:** 1723 mm
- **Moisture availability period:** 180-210 days

Soil and water conservation

Bilaspur

- Broad bed furrow
- Sowing across the slope
- Contour farming
- Inter-plot water harvesting
- Raised bed and sunken system
- Rainwater harvesting and recycling: The technology for harvesting of rainwater from a field of 1 ha in a farm pond (0.09 ha) has to be dug in the field in such a way that 2/3 area falls above the pond and 1/3 area falls below the pond. The upland area is used for growing upland crops like soybean, pigeonpea and lower area for growing rice. About 28 to 37 percent of total rain is collected as runoff in Vertisols, which is harvested in the tank.

Durg

- Sowing across the slope
- Contour farming
- Rainwater harvesting and recycling: The technology for harvesting of rainwater from a field of 1 ha in a farm pond (0.09 ha) has to be dug in the field in such a way that 2/3 area falls above the pond and 1/3 area falls below the pond. The upland area is used for growing upland crops like soybean, pigeonpea and lower area for growing rice. About 28 to 37 per cent of total rain is collected as runoff in Vertisols, which is harvested in the tank.

Raipur

- Sowing across the slope
- Contour farming
- Rainfed and sunken system

Crop management

Bilaspur, Durg, Raipur

- **Varieties:** Ujjain - 21, ICCV -37, JG 315, Vijaj, Pusa 391, JG 322, JG218
- **Seed rate:** 80 -100 kg/ha

- **Planting pattern:** 30 x 10 cm
- **Nutrient management:** 20 kg N + 40 kg P₂O₅ + 20 KG K₂O +20 Kg S /ha
- **Pest management**
- For Cut worms and *Helicoverpa armigera*
- Follow IPM package for effective management of gram pod borer, use pheromone traps to monitor moth population, spray 5 % NSKE followed by NPV 250 L.E. and endosulfan (35 EC) 0.07 % if necessary.
- Dust with Chlorpyrifos 2% dust @ 25 kg/ha in soil before sowing.
- **Some other important practices**
 - Sowing in first fortnight of October
 - Under rainfed conditions, after soybean, application of 50% of recommended dose of fertilizer to chickpea is adequate to realise optimum productivity.

Suitable cropping systems

Bilaspur, Durg, Raipur

- Maize/ sorghum in *Kharif* - Chickpea/ safflower in *Rabi*
- Greengram/ blackgram in *Kharif* - Safflower/ chickpea in *Rabi*

Farm implements/ tools

Bilaspur

- Manually operated low cost irrigation pump: This is a low cost manually operated pump has been developed to lift the stored water from *nalas*, ponds and *dhodhis* etc., (locally available water resources) for small scale irrigation to different crops in the region. The pump is suitable to lift the water from 15-20 feet depth.
- The discharge capacity of the pump is 3500-4000 l/ha. The operators' arms as well as legs are used for its operation to increase the efficiency. The cost of the pump is about Rs. 1000/-, producing 2-3 times more water delivery than local water lifting devices (*Dhenchly*) being utilized in the region.
- The mould board plough: For giving high clod conversion (60%) and field capacity (0.045 ha/hr). Lohia plough with minimum draft power (45.50 kg) was suitable for *biasi* operation.
- The bullock drawn disc efficient field preparation during *rabi* and summer.
- Puddlers: Bullock drawn Agro puddler and Riding Puddler
- Weeders: Ambika paddy weeder for efficient weed management.

Durg

- **Suitable implements for seedbed preparations**
 - Meston Plough
 - Iron Bakhar
- **Suitable implements for sowing operations**
 - Mahakal Dufan
 - Mahakal Tifan and
 - Sarta attachment for intercropping

- **Suitable implements/ tools for interculture operations**

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

Raipur

- Dryland weeder

Alternate farming systems

Bilaspur

- **Agri-horti system:** Mango + pea/ berseem (green fodder)/ wheat/ chickpea/ soybean
- **Silvi-pastoral system:** Teak + sudan grass
- **Fodder/ green biomass:** *Leucaena leucocephala*, *Albizia amara*, *Dichrostachys cineraria*, *Melia azadirach*, *Hardwickia binata*, *A.lebbeck*
- **Fruits:** Mango, ber, guava, tamarind, karonda
- **Medicinal and aromatic plants:** *Safed musli*, *Palmarosa*, *Withamnia somnifera*, *Papaver somniferum*, *Vetiveria zizanioides*
- **Vegetables:** Brinjal, chilli, cowpea, okra, bottle gourd, round melon.
- **Animal component:** Female and male cattle, female buffaloes, goats
- **Horticulture:**
 - Promising mango varieties recommended for different purposes are as follows:
 - Langra - Banarasi, Dasherri, Bombay Green (Table varieties)
 - Rani Pasand (Sucking)
 - Batasiya and Bitter gourd (Karela) (Pickle & *murabba*)
 - In newly planted mango orchards, intercropping with vegetables and legume crops (upto 5-7 years) found to be economical.
 - Jharberi (*Ziziphus rotundifolia*) can easily be converted by budding into improved varieties.
 - Lucknow-49 is recommended for guava cultivation.
 - In ginger, addition of NPK @ 150:50:100 kg/ha gave highest yield.
 - In turmeric, NPK application @ 135:90:90 kg/ha was found to be the best.
- **Agro-horticulture**
 - Inter cropping of ginger, okra, cowpea, groundnut, soybean, blackgram and pigeonpea were recommended in mango orchard plantation.
- **Silviculture**
 - The multipurpose tree species with fast growth rate are Khamhar (*Gmelina arborea*), Shisham (*Dalbergia sissoo*), Poplar (*Populus deltoides*), Bakain, Cassuarina spp., Archasia spp., *Cassia siamea* and Acacia spp.
 - Poplar (*Populus deltoides*), Shisham (*Dalbergia sissoo*), Khamhar (*Gmelina arborea*) and Siris (*Albizia lebeck*) are recommended for silviculture.

Durg

- **Fodder/green biomass:** *Albizzia lebbeck*, *Leucaena leucocephala*, *Dalbergia sissoo*, *Azadirachta indica*, *Sesbania*, *Pongamia*
- **Fruits:** Ber, mango, sapota, tamarind, fig
- **Medicinal and aromatic plants:** *Papaver somniferum*, *Rauvolfia*, *Liquorice*, *Safed musli*, *Palmarosa*
- **Vegetables:** Tomato, okra, bottle gourd, ridgegourd, amaranthus, drumstick
- **Animal component:** Female cattle, male cattle, female buffaloes, male buffaloes
- **Horticulture**
 - Promising mango varieties recommended for different purposes are as follows:
 - Langra - Banarasi, Dasherri, Bombay Green (Table varieties)
 - Rani Pasand (Sucking)
 - Batasiya & Bitter gourd (Karela) (Pickle & *murabba*)
- **Agri-horticulture**
 - In newly planted mango orchards, intercropping with vegetables and legume crops (upto 5-7 years) found to be economical.
 - Jharberi (*Ziziphus rotundifolia*) can easily be converted by budding into improved varieties.

Raipur

- **Agro-horti system:** Mango + pea/ berseem (green fodder)/ wheat/ chickpea/ soybean
- **Silvi-pastoral system:** Teak + sudan grass
- **Fodder/ green biomass:** *Leucaena leucocephala*, *Albizzia amara*, *Dichrostachys cinerea*, *Melia azadirach*, *Hardwickia binata*, *Albizzia lebbeck*
- **Fruits:** Mango, ber, guava, tamarind, karonda
- **Medicinal and Aromatic Plants:** *Safed musli*, *Palmarosa*, *Withamnia somnifera*, *Papaver somniferum*, *Vetiveria zizanooides*
- **Vegetables:** Brinjal, chilli, cowpea, okra, bottle gourd, round melon
- **Animal component:** Female cattle, male cattle, female buffaloes, goats

Contingent planning

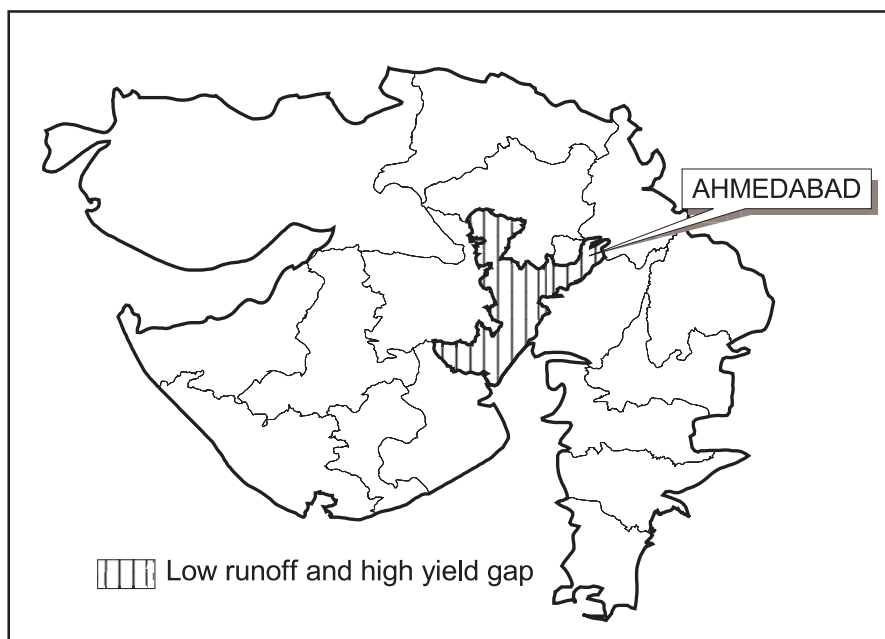
Bilaspur, Durg, Raipur

- **June**
 - **Sole crop**
 - Sorghum (CSH 5, JS 1041)
 - Greengram (K 851)
 - Blackgram (JU 2, PDU 4)
 - Groundnut (Jawahar, Jyoti, M 13)
 - **Inter crop**
 - 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 (JA 4, Asha)
 - Groundnut (Jyoti, M 12, Exotic 1-1, BSMR 736)
 - **Inter crop**
 - Sorghum + pigeonpea (2:1)
 - Soybean + pigeonpea (4:1)
- **August**
 - Castor (GCH 4, Kranthi)
 - Pigeonpea (No.148)
- **October**
 - Wheat (JW 17, C 306)
 - Chickpea (JG 322, JG 315)
 - Linseed (JL 23, R 552)
 - Barley (Karan 4, Jyoti)
 - Lentil (JL 1, Malikas, JL 3)

GUJARAT

In Gujarat there is one district viz. Ahmedabad with low runoff and high yield gap.



District	Region
Ahmedabad	Low runoff and high yield gap

Agro-geographic setting

Ahmedabad

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

Soil and water conservation

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

Crop management

- **Varieties:** G-12, ICCV-2 and Chaffa
- **Seed rate:** 75 kg/ha
- **Planting pattern:** 30 x 10 cm
- **Nutrient management:** 25 kg N + 50 kg P₂O₅/ha
- **Pest management**
 - Pod borer management - NPV culture extract of 500 caterpillars in 500 l of water/ha or Methyl parathion (2% dust) 20 kg/ha or Quinalphos (25 EC) one litre in 500 l of water per ha
- **Some other important practices:** Seed inoculation with Rhizobium

Suitable cropping systems

- Groundnut - chickpea
- Sesame - chickpea

Farm implements/ tools

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

Alternate farming systems

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

Contingent planning

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

- **Drought spell after normal sowing**

- 1-2 weeks after sowing:

- Resowing of early duration varieties or alternate crops should be recommended as under, if sufficient rainfall is received. Hybrid pearl millet (GHB-235, GHB-316, GHB-558), sorghum (GJ-39, J-41), sesame (G.Sesame-1, G-Sesame-2) and castor (GCH 4 or other hybrids, Kranthi), blackgram (T-9, TPU-4)

- 3-5 weeks after sowing:

- Agricultural operations like interculturing, weeding, hoeing and mulching may be taken up, if drought spell prolongs for two weeks or more weeks. The ratooning of sorghum may be done and top dressing of fertilizer should be suggested if sufficient rainfall after 3-5 weeks dry spell

- **Early withdrawal of monsoon**

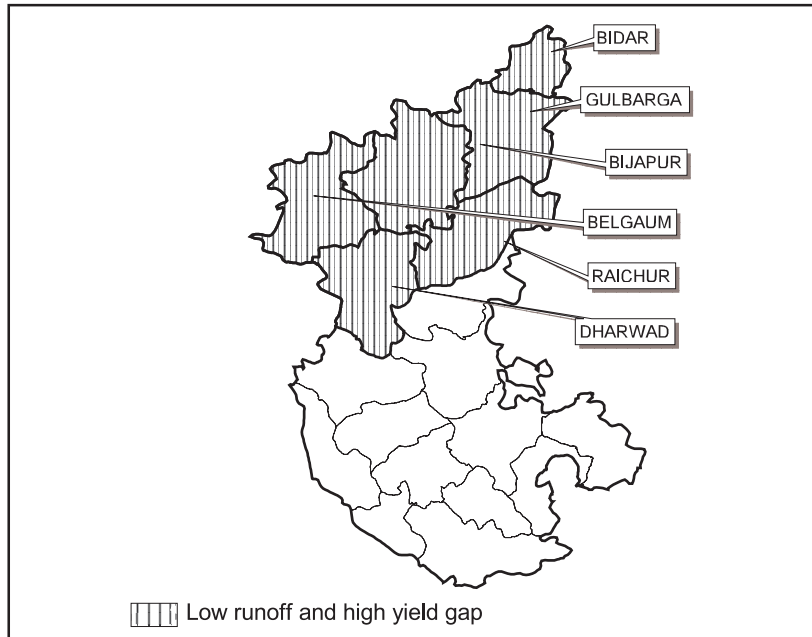
- Give life saving irrigation
- Minimize moisture losses through complete removal of weeds
- Perform interculturing to conserve soil moisture
- Harvest the crop according to maturity of crop duration
- Thin the plant population

- **Satisfactory late rains during September - October**

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

KARNATAKA

In Karnataka there are six districts viz. Belgaum, Bidar, Bijapur, Dharwad, Gulbarga and Raichur with low runoff and high yield gap.



District	Region
Belgaum Bidar Bijapur Dharwad Gulbarga Raichur	Low runoff and high yield gap

Agro-geographic setting

Belgaum

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

Bidar

- **Climate:** Hot semi arid
- **Physiography:** North Karnataka plateau (East)

- **Soils:** Shallow and medium loamy, medium and deep clay black soils (Vertic Inceptisols - 100%)
- **Annual rainfall:** 977 mm
- **Potential evapotranspiration:** 1755 mm
- **Moisture availability period:** 120 - 150 days

Bijapur

- **Climate:** Hot arid
- **Physiography:** Northern 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

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

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

Belgaum

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

Bidar

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

Bijapur

- Rubbles at 0.3 m vertical interval on contour key lines
- Compartement 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, 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* moisture conservation practices like compartment bunding, ridges and furrows, contour cultivation and fall ploughing helped to conserve more moisture in deep black soils

Dharwad, Gulbarga

- Rubbles at 0.3 m vertical interval on contour key lines
- Compartement bunding, ridges and furrows, contour cultivation
- Planting khus grass and subabul in paired rows at vertical interval of 0.3 m
- Bund stabilisation 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

Raichur

- Supplemental irrigation with harvested water
- Emphasis should be on farmer oriented soil conservation measures like *in situ* conservation measures
- Plant sunhemp in *rabi* areas

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

Crop management

Belgaum, Bidar, Bijapur, Dharwad, Gulbarga, Raichur

- **Varieties:** A - 1, Bharathi, JG 11
- **Seed rate:** 60 - 65 kg/ha
- **Planting pattern:** 30 X 10 cm
- **Nutrient management:** 25 kg N + 40 kg P₂O₅ +20 Kg K₂O+20 Kg S /ha
- **Pest management**
 - Pod borer management - Follow IPM package, intercrop with coriander, safflower monitor moth population, spray 5 % NSKE followed by NPV 250 L.E. and endosulfan (35 EC) 0.07 % or Methyl parathion (2% dust) 20 kg/ha or Quinalphos (25 EC) one liter in 500 l of water per ha
- **Some other important practices:** Seed inoculation with Rhizobium

Suitable cropping systems

Belgaum, Bidar, Bijapur, Dharwad, Gulbarga, Raichur

- Chickpea + safflower / coriander (3:1 or 4:2)
- *Rabi* sorghum + chickpea (2:1)
- Fingermillet + chickpea
- Greengram + chickpea

Farm implements/ tools

Belgaum, Bidar

- Wooden plough (Bullock drawn): Shallow ploughing to a depth of 10 cm. Rs.2000/-
- MB plough (Bullock drawn): Deep ploughing. Rs.4000/-
- MB plough (Tractor drawn): Deep ploughing. Rs.15000/-
- Blade harrow (Bullock drawn): Harrowing. Rs.1000/-
- Blade harrow (Tractor drawn): For harrowing. Rs.10000/-
- Seed cum fertilizer drill (Bullock drawn): For sowing and fertilizer application. Rs.2500/-
- Seed cum fertilizer drill (Bullock drawn - adjustable): Sowing and fertilizer application simultaneously. Rs.4500/-
- Seed cum fertilizer drill (Tractor drawn): For sowing and fertilizer application. Rs.26000/-

- Ridger: Ridges and furrows. Rs.1000/-
- Bund former: Compartment bund. Rs.700/-
- Slit hoe: Hoeing operation. Rs.500/-
- Blade hoe: Intercultivation operations. Rs.500/-
- Wooden float: Clod breaking. Rs.600/-
- Buck scraper: For leveling. Rs.2500/-
- Scooper: For scooping. Rs.500/-
- Multi furrow opener (Tractor drawn): For opening of furrows. Rs.15000/-
- Cultivator (Tractor drawn): For cultivating. Rs.15000/-
- Rotovator (Tractor drawn): For incorporation of residues and green manures. Rs.45000/-

Bijapur, Dharwad, Gulbarga, Raichur

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

Alternate farming systems

Belgaum, Bidar, Bijapur, Dharwad, Gulbarga, Raichur

- Agave (*Agave sisolana* with 10,000 plants/ha) intercropped with subabul. Cutting of agave leaves once in a year for fibre extraction with retaining top ten leaves
- **Silviculture:** Shallow black soils: *Cassuarina*, *Dalbergia sissoo*, *Hardwickia binata*, *Acacia nilotica*, *Prosopis cineraria*, Marginal land: *Dalbergia sissoo*, neem, *Acacia nilotica*, *Leucaena*
- **Alley cropping:** *Leucaena* / *Cassuarina* + *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 lebbek*, *Hardwickia binata*, *Cassia siamea*, *Azadirachta indica*
- **Fruits:** Mango, pomegranate, sapota, ber, jamun, tamarind
- **Medicinal/ Aromatic Plants:** *Cassia angustifolia*, *Catharanthus roseus*, *Palmarosa*, *Vetiveria zizanioides*, Rose, Geranium
- **Vegetables:** Onion, brinjal, chillies, cowpea, cucumber, cluster bean, drumstick.
- **Animal component:** Male/ female cattle, female buffaloes, sheep, goat, poultry

Contingent planning

Belgaum, Bidar, Bijapur, Dharwad, Gulbarga, Raichur

Normal onset of monsoon favourable for *kharif* crops

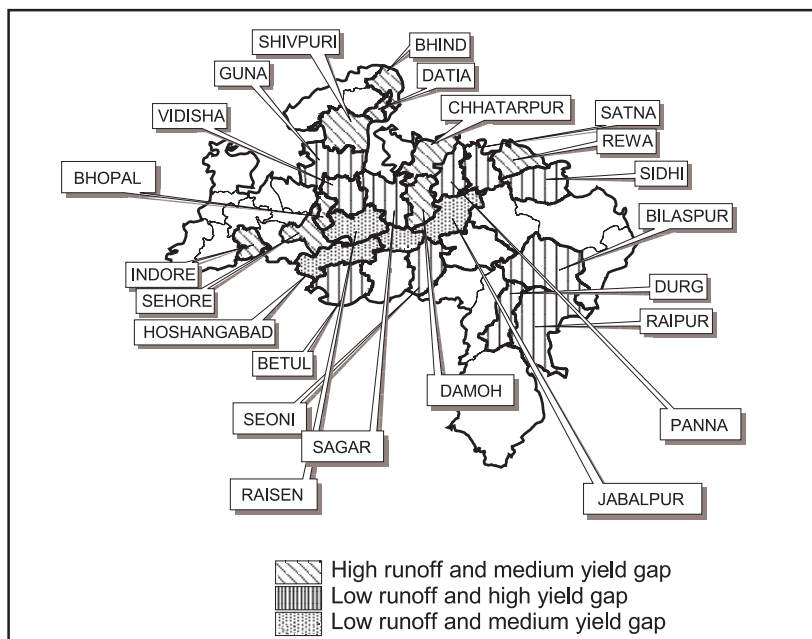
- Take up sowing of the following crops in June in light soils. Groundnut (erect and spreading), pearl millet, pigeonpea, *kharif* sorghum, setaria, hybrid sorghum and other crop mixtures like *kharif* sorghum + pigeonpea (2:1), groundnut + pigeonpea (4:2), setaria + pigeonpea (2:1) and pearl millet

- + pigeonpea (2:1). Similarly, pulse crops in light and retentive soils may be taken up.
- In *rabi* areas, i.e., medium deep black soils, sow greengram, blackgram, cucumber as a first crop to be followed by *rabi* sorghum/ sunflower/ chickpea/ safflower/ wheat.
- When the land is kept fallow (deep black soils) for *rabi* crops, have compartment bunds having 1 per cent slope, scooping where the land slope is 1 to 2 per cent, ridges and furrows or tied ridges for better soil and moisture conservation. Take up harrowings after each rain, which helps in controlling weeds and conserving soil moisture.
- Sow sunhemp as green manuring crop in medium to deep black soils prior to *rabi* crops.
- **Normal onset of monsoon but dry spells soon after germination**
 - Give protective irrigation for the crops sown wherever possible.
 - Ratoon pearl millet, sorghum for rejuvenation after rains.
 - For crops like groundnut, take up urea spray (2% solution) immediately after rains for quick revival.
 - When the sown crops completely wither, plant setaria, dolichos, horsegram, matki, cowpea and sunflower soon after revival of rains.
- **No normal rains in June but onset of rains in July**
 - Sow groundnut (bunch), 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 *Hirsutum*s. 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 1½ times the normal seed rate relatively at depth without applying chemical fertilizer. Fertilizer may be applied at appropriate growth stage having optimum moisture condition.
- **Sowings in October**
 - Continue sowing of *rabi* sorghum and sesame upto October 15th with 50 per cent recommended level of fertilizer.

- Follow cropping of *rabi* sorghum + chickpea in 2:1 row proportion.
- Sow *rabi* sorghum and chickpea as mixed crops (random mixing)
- Increase the area under safflower.
- Sow chickpea and safflower in 4:2 or 3:1 row proportions for higher returns.
- Top dress *rabi* sorghum with 10-15 kg N/ha if adequate moisture is available in the soil.
- Early stoppage of rains towards the end of season
- Thin out the population of *rabi* sorghum by blading every third row or alternate row within 40 days of sowing.
- In mixed crops of *rabi* sorghum and safflower, uproot *rabi* sorghum component.
- Close soil cracks by repeated interculturing.
- Provide supplemental irrigation through farm ponds or other sources. By providing one or two supplemental irrigation(s) to *rabi* sorghum, safflower and chickpea, yields could be increased by 50 to 60 per cent.
- 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.

MADHYA PRADESH

In Madhya Pradesh there are four districts viz. Hoshangabad, Jabalpur, Narasinghpur and Raisen with low runoff and medium yield gap, nine districts viz. Betul, Guna, Mandla, Panna, Sagar, Satna, Seoni, Sidhi and Vidisha with low runoff and high yield gap, and ten districts viz. Bhind, Bhopal, Chattarpur, Damoh, Datia, Dewas, Indore, Rewa, Sehore and Shivpuri with high runoff and medium yield gap.



District	Region
Betul	Low runoff and high yield gap
Guna	
Mandla	
Panna	
Sagar	
Satna	
Seoni	
Sidhi	
Vidisha	

Agro-geographical 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

Guna

- **Climate:** Hot dry/ moist semi arid
- **Physiography:** Vindhyan scarplands
- **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

Mandla

- **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

Panna

- **Climate:** Hot dry sub humid
- **Physiography:** Vindhyan scraplands
- **Soils:** Deep loamy to clayey mixed red and black soils (Vertic Inceptisols - 100%)
- **Annual rainfall:** 1186 mm
- **Potential evapotranspiration:** 1436 mm
- **Moisture availability period:** 150 - 180 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

Satna

- **Climate:** Hot dry sub humid
- **Physiography:** Baghel Khand plateau (Central highlands)
- **Soils:** Deep loamy to clayey mixed red and black soils (Vertic Inceptisols - 100%)
- **Annual rainfall:** 1138 mm
- **Potential evapotranspiration:** 1452 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

Sidhi

- **Climate:** Hot dry sub humid
- **Physiography:** Baghel Khand plateau
- **Soils:** Deep loamy to clayey mixed red and black soils (Alfisols/ Ustolls - 75%; Vertic Inceptisols - 25%)
- **Annual rainfall:** 1174 mm
- **Potential evapotranspiration:** 1468 mm
- **Moisture availability period:** 150 - 180 days

Vidisha

- **Climate:** Hot dry sub humid
- **Physiography:** Vindhyan scarplands
- **Soils:** Medium and deep clayey black soils, shallow loamy black soils (Vertic Inceptisols - 60%; Vertisols - 40%)
- **Annual rainfall:** 1331 mm
- **Potential evapotranspiration:** 1539 mm
- **Moisture availability period:** 220 days

Soil and water conservation

Vidisha

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

Betul, Guna, Sagar, Seoni

- Straighten the gullied portion in the farmers' fields through earth moving machinery to reduce the length of gully allowing safe passage for the runoff water. It brings additional area under cultivation through reclamation process.
- Construct a percolation tank for increasing groundwater recharge and enhancing groundwater 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 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 rainwater.
- Develop a sort of terracing to break the continuity of undulating slope to reduce the changes of degrading cultivated fields into 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.

Mandla

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

Panna, Satna, Sidhi

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

Crop management

Betul, Guna, Vidisha

- **Varieties:**
 - JG 74, JG315, Vijay, JG 218, Radhey and Avrodhi
 - Sunflower + chickpea
 - Sorghum + chickpea
 - Sorghum (fodder) + chickpea
 - Barley + chickpea (2:1)
 - Seed inoculation with Rhizobium
- **Seed rate:** 80 kg/ha

- **Planting pattern:** 30 cm rows
- **Nutrient management:** 25 kg N + 40 kg P₂O₅ + 20 kg K₂O + 20 kg S /ha
- **Pest management:**
 - For Cut worms and *Helicoverpa armigera*
 - Dust with Chloropyriphos 2% dust @ 25 kg/ha in soil before sowing.
 - Spray Endosulphan 35 EC @ 2 ml/ l of water or spray NPV @ 250 LE/ ha and alternate with 5 % NSKE

Mandla, Sagar, Seoni

- **Varieties:** Ujjain - 24, ICCV - 21 and ICCV -37
- **Seed rate:** 80 -100 kg/ha
- **Planting pattern:** 30 x 10 cm
- **Nutrient management:** 20 kg N + 40 kg P₂O₅/ha
- **Pest management:**
 - For Cut worms and *Helicoverpa armigera*
 - Dust with Chloropyriphos 2% dust @ 25 kg/ha in soil before sowing.
 - Spray Endosulphan 35 EC@ 2 ml/ l of water or spray NPV @ 250 LE/ ha
- **Some other important practices**
 - Sowing in first week of October
 - Under rainfed conditions, after soybean, application of 50% of recommended dose of fertilizer to chickpea is adequate to realise optimum productivity.

Panna, Satna, Sidhi

- **Varieties:** BG 256, RWG 3, JG-15, JG 74, Vijay
- **Seed rate:** 80 kg/ha
- **Planting pattern:** 30 cm rows
- **Nutrient management:** 20 kg N + 40 kg P₂O₅/ha
- **Pest management:**
 - For Cut worms and *Helicoverpa armigera*
 - Dust with Chloropyriphos 2% dust @ 25 kg/ha in soil before sowing.
 - Spray Endosulphan 35 EC@ 2 ml/ l of water or spray NPV @ 250 LE/ ha

Suitable cropping systems

Mandla, Sagar, Seoni

- Maize/ sorghum in *kharif* - chickpea/ safflower in *rabi*
- Greengram/ blackgram in *kharif* - safflower chickpea in *rabi*

Panna, Satna, Sidhi

- Soybean - chickpea
- Wheat + chickpea
- 20:40:0 the fertilizer should be applied at sowing; preferably with Dufar (seed cum fertilizer drill below the seed)

Farm implements/ tools

Betul, Guna, Sagar, Seoni, Vidisha

- 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 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

Panna, Satna, Sidhi

- Dryland weeder

Alternate farming systems

Betul, Guna, Vidisha

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

Mandla, Seoni

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

Sagar

- **Agro-horti system:** Mango + pea/ berseem (green fodder)/ wheat/ chickpea/ soybean
- **Silvi-pastoral system:** Teak + sudan grass
- **Fodder/ green biomass:** *Dichrostachys cineria*, *Albizia amara*, *Faidherbia albida*, *Hardwickia binata*, *Cassia*, *Leucaena leucocephala*, *Albizia lebbbeck*

- **Fruits:** Ber, pomegranate, mango, fig, tamarind
- **Medicinal/ Aromatic Plants:** *Withamnia somnifera*, *Rauvolfia serpentina*, *Vetiveria zizanioides*, *Palmarosa*, *Liquorice*
- **Vegetables:** Chillies, okra, watermelon, cowpea, cluster bean, amaranthus, round melon
- **Animal component:** Male/ female cattle, female buffaloes, sheep, goat

Panna, Satna, Sidhi

- **Agro-horti system:** Mango + pea/ berseem (green fodder)/ wheat/ Chickpea/ Soybean
Mango/ guava/ amla + field crops (wheat, barley, pulses and oilseeds) (Satna)
- **Silvi-pastoral system:** Teak + sudan grass
- **Fodder/ green biomass:** *Leucaena leucocephala*, *Albizia amara*, *Dichrostachys cineraria*, *Melia azadirach*, *Hardwickia binata*, *Albizia lebbeck*
- **Fruits:** Mango, ber, guava, tamarind, karonda
- **Medicinal and aromatic plants:** *Safed musli*, *Palmarosa*, *Withamnia somnifera*, *Papaver somniferum*, *Vetiveria zizanioides*
- **Vegetables:** Brinjal, chilli, cowpea, okra, bottle gourd, round melon
- **Animal component:** Female cattle, male cattle, female buffaloes, goats

Contingent planning

Betul, Guna, Sagar, Seoni

- **15th to 31st July**
 - Maize (short duration varieties like Navjot, Sathi)
 - Pigeonpea (ICPL 151, T-21, Kh-2, ICPL 87 GT 100) under deep soils preferred varieties
 - Sunflower (Morden, Surya, Manjira, any hybrid)
 - Sesame (Bhadeli, TKG 22, TKG 37)
 - Cowpea (Pusa Komal, Pusa Baisakhi)
 - Castor (GCH 4 , Kranthi)
 - Fodder crops (*Sorghum sudanensis*, maize (African tall), Dinanath grass, pearl millet)
- **1st to 15th August**
 - Sunflower (Morden, Surya, Manjira, any hybrid)
 - Sesame (Bhadeli, TKG 22, TKG 37)
 - Cowpea (Pusa Komal, Pusa Baisakhi)
 - Rajgira (Amaranthus) - (CO-1, CO-2)
 - Fodder crops (*Sorghum sudanensis*, maize (African tall), Dinanath grass, pearl millet)
- **15th to 31st August**
 - Safflower (JSF-1, JSF-7 (spineless), JSF-73 and Sharda)
 - Sunflower (Morden, Surya, Manjira)
 - Sesame (Bhadeli, TKG 22, RT-46)
 - Rajgira (Co-1, Co-2)
 - Castor (GCH 4 or other hybrids, Kranthi)
 - Fodder crops (Barley, oats, maize (African tall), safflower, sunflower)

Mandla, Panna, Seoni, Sidhi

- **June**
 - **Sole crop**
 - Sorghum (CSH 5, JS 1041)
 - Greengram (K 851)
 - Blackgram (JU 2, TPU 4)
 - Groundnut (Jawahar, Jyoti, M 13)
 - **Inter crop**
 - 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, other hybrids)
 - Pigeonpea (JA4, Asha, BSMR 736, BSMR 853)
 - Groundnut (Jyoti, M 12, Exotic 1-1)
 - **Inter crop**
 - Sorghum + pigeonpea (2:1)
 - Soybean + pigeonpea (2:1)
- **August**
 - Castor (Kranthi, other hybrids)
 - Pigeonpea (No.148)
- **October**
 - Wheat (JW 17, C 306)
 - Chickpea (JG 74, JG 315)
 - Linseed (JL 23, R 552)
 - Barley (Karan 4, Jyoti)
 - Lentil (JL 1, Malika)

Satna

- **Normal season**
 - Rice
 - Very early group - less than 95 days (Prasanna, Vandana, JR 3-45)
 - Early group - 95 to 115 days (IR-64, IR 50, Basmati)
 - Medium duration - 125 to 145 days (IR-36, Jaya, Kranthi)
 - Sorghum (CSH 5, CSH 6, other hybrids)
 - Maize (Ganga-1, Ganga 5, other hybrids)
 - Pigeonpea (NP (WR) 15)

- Soybean (JS 335)
- Sesame (JT 7)
- Groundnut (Jawahar, Jyothi-1)
- Kodo kutki (J.kodo 136, J. kutki)
- Blackgram (JU 2, TPU 4, Bant U 19)
- Greengram (K 851, JM 45)
- **Intercropping**
 - Sorghum + pigeonpea (2:1)
 - Soybean + pigeonpea (2:1)
- **Late season**
 - Rice - late variety (IR 50, JR 3-45)
 - Kodo (JK 155)
 - Sorghum (CSH 5, other hybrids)
 - Pigeonpea (JA 4, Asha)
 - Groundnut (Exotic 1-1)
 - Blackgram (TPU 4, Bant U 19Y)
 - Sesame (JT-1)
 - Safflower (JSF 1)
 - Sunflower (Morden, other hybrids)
- **Late season drought**
 - Harvested rainwater recycled as life saving irrigation
- **Lowland - Direct seeded**
 - Re-sowing of rice is needed if plant population is less than 50%
 - Weeds are uprooted by manual weeding practice
 - Spray of insecticide make sure if attack of insect pest observed
 - Spraying of micronutrient if deficiency is noticed

District	Region
Bhind Bhopal Chattarpur Damoh Datia Dewas Indore Rewa Sehore Shivpuri	High runoff and medium yield gap

Agro-geographical setting

Bhind

- **Climate:** Hot moist semi arid
- **Physiography:** Satpura ranges

- **Soils:** Deep loamy alluvium - deveried soils (Vertic Inceptisols - 100%)
- **Annual rainfall:** 1148 mm
- **Potential evapotranspiration:** 1484 mm
- **Moisture availability period:** 120 - 150 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

Chattarpur

- **Climate:** Hot dry sub humid
- **Physiography:** Vindhyan scraplands
- **Soils:** Deep loamy to clayey mixed red and black soils (Vertic Inceptisols - 80%; Inceptisols- 20%)
- **Annual rainfall:** 1044 mm
- **Potential evapotranspiration:** 1429 mm
- **Moisture availability period:** 150 - 180 days

Damoh

- **Climate:** Hot dry sub humid
- **Physiography:** Vindhyan Scraplands (Central highlands)
- **Soils:** Medium and deep clayey black soils, shallow loamy black soils (Vertic Inceptisols - 60%; Vertisols - 40%)
- **Annual rainfall:** 1218 mm
- **Potential evapotranspiration:** 1449 mm
- **Moisture availability period:** 150-180 days

Datia

- **Climate:** Hot moist semi arid
- **Physiography:** Madhya Bharat plateau
- **Soils:** Deep loamy and clayey mixed red and black soils (Vertic Inceptisols - 100%)
- **Annual rainfall:** 973 mm
- **Potential evapotranspiration:** 1512 mm
- **Moisture availability period:** 210 days

Dewas

- **Climate:** Hot dry/ moist sub humid
- **Physiography:** Malwa plateau
- **Soils:** Deep clayey black soils and shallow black soils (Vertic Inceptisols - 100%)

- **Annual rainfall:** 1079 mm
- **Potential evapotranspiration:** 1707 mm
- **Moisture availability period:** 120 - 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

Rewa

- **Climate:** Hot dry sub humid
- **Physiography:** Baghel Khand plateau (Central highlands)
- **Soils:** Deep loamy to clayey mixed red and black soils (Vertic Inceptisols - 60%; Inceptisols - 25%; Ustalf/ Ustolls - 15%)
- **Annual rainfall:** 1079 mm
- **Potential evapotranspiration:** 1453 mm
- **Moisture availability period:** 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

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

Bhind

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

Bhopal, Dewas, Indore, Sehore

- 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 runoff 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 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 rainwater.
- Develop a sort of terracing to break the continuity of undulating slope to reduce the changes of degrading cultivated fields into 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.

Chattarpur, Damoh, Rewa

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

Datia

- Sowing across the slope and ridging later
- Compartment bunds for raising crops on conserved soil moisture

Shivpuri

- Compartment bunding after seeding 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
- Gully plugging

Crop management

Bhind

- **Varieties:** BG 256, Gaurav and K 850, JG 315, Vijay
- **Seed rate:** 70 - 75 kg/ha
- **Planting pattern:** 30 x 10 cm
- **Nutrient management:** 10-15 kg N + 60 P₂O₅ kg/ha and full dose of N and P as Basal at 10 cm depth
- **Pest management:** Aphids and pod borer: Spray with systemic insecticide Endosulphan 35 E.C.
- **Some other important practices:** Seed treatment with rhizobium culture

Bhopal, Dewas, Indore, Sehore

- **Varieties:** Ujjain - 24, ICCV - 21 and ICCV -37, JG 315, JG 74
- **Seed rate:** 80 -100 kg/ha
- **Planting pattern:** 30 x 10 cm
- **Nutrient management:** 20 kg N + 40 kg P₂O₅/ha
- **Pest management:**
 - For Cut worms and *Helicoverpa armigera*
 - Dust with Chloropyriphos 2% dust @ 25 kg/ha in soil before sowing.
 - Spray Endosulphan 35 EC @ 2 ml/ l of water or spray NPV @ 250 LE/ ha
- **Some other important practices**
 - Sowing in first week of October
 - Under rainfed conditions, after soybean, application of 50% of recommended dose of fertilizer to chickpea is adequate to realise optimum productivity.

Chattarpur

- **Varieties:** Ujjain - 21, JG-218, JG-315, JG 322 and Phule G-5
- **Seed rate:** 80 kg/ha
- **Planting pattern:** 30 cm rows
- **Nutrient management:** 20 kg N + 40 kg P₂O₅/ha
- **Pest management:**
 - For Cut worms and *Helicoverpa armigera*
 - Dust with Chloropyriphos 2% dust @ 25 kg/ha in soil before sowing.
 - Spray Endosulphan 35 EC @ 2 ml/ l of water or spray NPV @ 250 LE/ ha

Damoh, Rewa

- **Varieties:** BG 256, JG-315, JG 74, H 208, and Vishal
- **Seed rate:** 80 kg/ha

- **Planting pattern:** 30 cm rows
- **Nutrient management:** 20:40:0 the fertilizer should be applied at sowing; preferably with Dufar (seed cum fertilizer drill below the seed)
- **Pest management:**
 - For Cut worms and *Helicoverpa armigera*
 - Dust with Chloropyriphos 2% dust @ 25 kg/ha in soil before sowing.
 - Spray Endosulphan 35 EC @ 2 ml/ l of water or spray NPV @ 250 LE/ ha

Datia, Shivpuri

- **Varieties:** Pusa 256, Vishal, JG 315, JG 218, Pusa 244
- **Seed rate:** 80 kg/ha
- **Planting pattern:** 30 X 10 cm
- **Nutrient management:** 20 kg N + 40 kg P₂O₅/ha
- **Pest management:** Pod borers cause maximum damage. For controlling Pod borer spray of 250 ml Dimecron or 1.5 l of Thiodin in 1000 l of water/ ha at the time of flowering and at pod formation is recommended
- **Some other important practices:** Seed inoculation with Rhizobium

Suitable cropping systems

Bhind

- Pearl millet + cowpea (fodder) - chickpea + rapeseed mustard

Bhopal, Dewas, Indore, Sehore

- Maize/ sorghum in *Kharif* - chickpea/ safflower in *Rabi*
- Greengram/ blackgram in *Kharif* - safflower/ chickpea in *Rabi*

Chattarpur

- Soybean - chickpea

Damoh, Rewa

- Soybean - chickpea
- Wheat + chickpea

Datia, Shivpuri

- Sunflower + chickpea
- Sorghum (fodder) + chickpea
- Barley + chickpea (2:1)

Farm implements/ tools

Bhind, Datia, Shivpuri

- Fertilizer cum seed drill

Bhopal, Dewas, Indore, Sehore

- 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 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

Chattarpur, Damoh, Rewa

- Dryland weeder

Alternate farming systems

Bhind

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

Bhopal, Dewas, Indore

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

Sehore

- **Agro-horti system:** Mango + pea/ berseem (green fodder)/ wheat/ chickpea/ soybean
- **Silvi-pastoral system:** Teak + sudan grass
- **Fodder/ green biomass:** *Dichrostachys cineraria*, *Albizia amara*, *Faidherbia albida*, *Hardwickia binata*, *Cassia*, *Leucaena leucocephala*, *Albizia lebbeck*

- **Fruits:** Ber, pomegranate, mango, fig, tamarind
- **Medicinal/ Aromatic Plants:** *Withamnia somnifera*, *Rauvolfia serpentina*, *Vetiveria zizanioides*, Palmarosa, *Liquorice*.
- **Vegetables:** Chillies, okra, watermelon, cowpea, cluster bean, amaranth, round melon
- **Animal Component:** Female cattle, male cattle, female buffaloes, goats

Chattarpur

- **Agro-horti system:** Mango + pea/ berseem (green fodder)/ wheat/ chickpea/ soybean
- **Silvi-pastoral system:** Teak + sudan grass
- **Fodder/ green biomass:** *Leucaena leucocephala*, *Albizia amara*, *Dichrostachys cineraria*, *Melia azadirach*, *Hardwickia binata*, *Albizia lebbeck*
- **Fruits:** Mango, ber, guava, tamarind, karonda
- **Medicinal/ Aromatic Plants:** *Safed musli*, *Palmarosa*, *Withamnia somnifera*, *Papaver somniferum*, *Vetiveria zizanioides*
- **Vegetables:** Brinjal, chilli, cowpea, okra, bottle gourd, round melon
- **Animal component:** Female cattle, male cattle, female buffaloes, goats

Damoh

- **Agro-horti system:** Mango/ guava/ amla + field crops (wheat, barley, pulses and oilseeds)
- **Alley cropping :** *Subabul* (4 m interval) + groundnut/ sesame/ cowpea (grain)
- **Fodder/ green biomass:** *Albizia lebbeck*, *Subabul*, *Dalbergia sissoo*, *Azadirachta indica*, *Sesbania*, *Pongamia*
- **Fruits:** Ber, mango, sapota, tamarind, fig
- **Medicinal and aromatic plants:** *Papaver somniferum*, *Rauvolfia*, *Liquorice*, *Safed musli*, *Palmarosa*
- **Vegetables:** Tomato, okra, bottle gourd, ridge gourd, amaranthus, drumstick
- **Animal component:** Female and male cattle, female buffaloes, male buffaloes

Rewa

- **Agro-horti system:** Mango + pea/ berseem (green fodder)/ wheat/ chickpea/ soybean
- **Silvi-pastoral system:** Teak + sudan grass
- **Fodder/green biomass:** *Leucaena leucocephala*, *Albizia amara*, *Dichrostachys cineria*, *Melia azadirach*, *Hardwickia binata*, *Albizia lebbeck*
- **Fruits:** Mango, ber, guava, tamarind and karonda
- **Medicinal and aromatic plants:** *Safed musli*, *Palmarosa*, *Withamnia somnifera*, *Papaver somniferum*, *Vetiveria zizanioides*
- **Vegetables:** Brinjal, chilli, cowpea, okra, bottle gourd, round melon
- **Animal component:** Female and male cattle, female buffaloes, goats

Datia

- **Fodder/ green biomass:** *Leucaena*, *Melia azadirach*, *Dichrostachys cineraria*, *Albizia amara*, *A.lebbeck*, *Hardwickia binata*, *A.nilotica*
- **Fruits:** *Emblica officinalis* (amla), guava, ber, mango

- **Medicinal/ Aromatic Plants:** *Rauvolfia serpentina*, *Vetivera zizanioides*, Palmarosa, *Safed musli*, *Aswaganetha*.
- **Vegetables:** Bottle gourd, brinjal, tomato, chillies, brinjal, cowpea, okra
- **Animal Component:** Female cattle, male cattle, female buffaloes, goats, poultry

Shivpuri

- **Agro-horti system:** Mango + pea/ berseem (green fodder)/ wheat/ chickpea/ soybean
- **Silvi-pastoral system:** Teak + sudan grass
- **Fodder/green biomass:** *Leucaena*, *Melia azadirach*, *Dichrostachys cineraria*, *Albizia amara*, *A.lebbeck*, *Hardwickia binata*, *Albizia nilotica*
- **Ley farming** - Four years continuous raising of *Stylosanthes hamata* followed by sorghum
- **Fruits:** *Emblia officinalis* (amla), guava, ber, mango
- **Medicinal and aromatic plants:** *Rauvolfia serpentina*, *Vetivera zizanioides*, *Palmarosa*, *Safed musli*, *Aswaganetha*
- **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

Bhind, 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 (TPU-4) 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 bold), barley (Ratna), chickpea (K 850), lentil (L 9-12), rapeseed (Jawahar toria 1) and safflower in the order.

Bhopal, Dewas, Indore, Sehore

- **15th to 31st July**
 - Maize (short duration varieties like Navjot, Sathi, other hybrids)
 - Pigeonpea (under deep soils preferred varieties ICPL 151, T-21, Kh-2, ICPL 87)

- Sunflower (Morden, Surya, Manjira, any hybrid)
- Sesame (Bhadeli, TKG 22, TKG 37)
- Cowpea (Pusa Komal, Pusa Baisakhi)
- Castor (GCH 4 or other hybrids, Kranthi)
- Fodder crops (*Sorghum sudanensis*, maize (African tall), Dinanath grass, pearl millet)
- **1st to 15th August**
 - Sunflower (Morden, Surya, Manjira, any hybrid)
 - Sesame (Bhadeli, TKG 22 and TKG 37)
 - Cowpea (Pusa Komal, Pusa Baisakhi)
 - Rajgira - Amaranthus (CO-1, CO-2)
 - Fodder crops (*Sorghum sudanensis*, maize (African tall), Dinanath grass, pearl millet)
- **15th to 31st August**
 - Safflower 9JSF-1, JSF- 7 (spineless), JSF-73, Sharda)
 - Sunflower (Morden, Surya, Manjira)
 - Sesame (Bhadeli, TKG 22, RT-46)
 - Rajgira (Co-1, Co - 2)
 - Castor (GCH 4 or other hybrids, Kranthi)
 - Fodder crops (Barley, oats, maize (African tall), safflower and sunflower)

Chattarpur

- **June**
 - **Sole crop**
 - Sorghum (CSH 5, JS 1041, other hybrids)
 - Greengram (K 851)
 - Blackgram (JU 2, TPU 4)
 - Groundnut (Jawahar Jyoti, M 13)
 - **Inter crop**
 - Sorghum + pigeonpea (2:1)
 - Soybean + pigeonpea (4:1)
- **July**
 - **Sole crop**
 - Rice (IR 50, JR 345)
 - Kodo (JK 155, JK 76, JK 136)
 - Sorghum (CSH 5, other hybrids)
 - Pigeonpea (JA4, Asha, BSMR 736, BSMR 853)
 - Groundnut (Jyoti, M 12, Exotic 1-1)

- **Inter crop**
 - Sorghum + pigeonpea (2:1)
 - Soybean + pigeonpea (2:1)
- **August**
 - Castor (GCH 4 , Kranthi, other hybrids)
 - Pigeonpea (No.148)
- **October**
 - Wheat (JW 17, C 306)
 - Chickpea (JG 312, JG 315)
 - Linseed (JL 23, R 552)
 - Barley (Karan 4, Jyoti)
 - Lentil (JL 1, Malika, JL3)

Damoh, Rewa

- **Normal season**
 - Rice
 - Very early group - less than 95 days (Prasanna, Vandana, JR 3-45)
 - Early group - 95 to 115 days (IR-64, IR 50, Basmati)
 - Medium duration - 125 to 145 days (IR-36, Jaya, Kranthi)
 - Sorghum (CSH 5, CSH 6, other hybrids)
 - Maize (Ganga 1, Ganga 5, other hybrids)
 - Pigeonpea (JA 4, Asha)
 - Soybean (JS 335)
 - Sesame (JT 7)
 - Groundnut (Jawahar, Jyothi-1)
 - Kodo kutki (J.kodo 136, J.kutki)
 - Blackgram (JU 2, TPU 4)
 - Greengram (K851, JM 45)
- **Intercropping**
 - Sorghum + pigeonpea (2:1)
 - Soybean + pigeonpea (2:1)
- **Late season**
 - Rice - late variety (IR 50, JR 3-45)
 - Kodo (JK 155)
 - Sorghum (CSH 5, other hybrids)
 - Pigeonpea (JA 4, Asha)

- Groundnut (Exotic 1-1)
- Blackgram (DU 4)
- Sesame (JT-1)
- Safflower (JSF 1)
- Sunflower (Morden)
- **Late season drought**
 - Harvested rainwater recycled as life saving irrigation
- **Lowland - Direct seeded**
 - Re-sowing of rice is needed if plant population is less than 50%
 - Weeds are uprooted by manual weeding practice
 - Spray of insecticide make sure if attack of insect pest observed
 - Spraying of micronutrient if deficiency is noticed

District	Region
Hoshangabad Jabalpur Narsinghpur Raisen	Low runoff and medium yield gap

Agro-geographical setting

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

Jabalpur

- **Climate:** Hot dry sub humid/ Hot moist sub humid
- **Physiography:** Narmada valley (Central highlands)
- **Soils:** Medium and deep clayey black soils, shallow loamy black soils, shallow to deep loamy to clayey mixed red and black soils (Vertic Inceptisols - 85%; Vertisols - 15%)
- **Annual rainfall:** 1447 mm
- **Potential evapotranspiration:** 1401 mm
- **Moisture availability period:** 150 - 180 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

Soil and water conservation

Hoshangabad, Narasinghpur, Raisen

- Straighten the gullied portion in the farmers' fields through earth moving machinery to reduce the length of gully allowing safe passage for the run off water. It brings additional area under cultivation through reclamation process.
- Construct percolation tank for increasing ground water recharge and enhancing ground water storage to provide extra irrigation to the crops.
- Use gabion as an inlet and outlet of water harvesting tank without any structural failure to trap silt on the upstream sit to increase life of water storage bodies.
- Construct water-harvesting tank to retain the excess run off from the water shed area to use stored water for irrigation purpose.
- Silpaulin (a plastic material) of 90 - 120 gsm has been found effective lining material for farm ponds used for water harvesting purposes.
- Use vegetative barriers to strengthen the mechanical bunds at suitable vertical intervals in order to reduce runoff in 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 per cent.
- Off-season shallow tillage is important not only in controlling the weeds but also in helping entry of rainwater.
- 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 as mulch @ 4-5 t/ha in between the rows of crop plants to minimize evaporative losses, moisture conservation and to increase moisture efficiency in *rabi* crops.

Jabalpur

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

Crop management

Hoshangabad, Narasinghpur, Raisen

- **Varieties:** Ujjain - 21, ICCV - 12, ICCV -37, JG 315, JG 218, GG 1
- **Seed rate:** 80 -100 kg/ha
- **Planting pattern:** 30 x 10 cm
- **Nutrient management:** 20 kg N + 40 kg P₂O₅/ha
- **Pest management:**
 - For Cut worms and *Helicoverpa armigera*
 - Dust with Chloropyriphos 2% dust @ 25 kg/ha in soil before sowing.
 - Spray Endosulphan 35 EC @ 2 ml/ l of water or spray NPV @ 250 LE/ ha
- **Some other important practices**
- Sowing in first week of October
- Under rainfed conditions, after soybean, application of 50% of recommended dose of fertilizer to chickpea is adequate to realise optimum productivity.

Jabalpur

- **Varieties:** BG 256, RWG 1, JG-15, JG 74, Vijay, GG 1
- **Nutrient management:** 20:40:0. The fertilizer should be applied at sowing; preferably with Dufar (seed cum fertilizer drill below the seed)
- **Pest management:** Pod borers cause maximum damage. For controlling pod borer spray of 50 ml Dimecron or 1.5 l. Thiodon in 1000 l of water/ ha at the time of flowering and at pod formation is recommended

Suitable cropping systems

Hoshangabad, Narasinghpur, Raisen

- Maize/ sorghum in *Kharif* - chickpea/ safflower in *rabi*
- Greengram/ blackgram in *Kharif* - safflower/ chickpea in *rabi*

Jabalpur

- Soybean - chickpea
- Wheat + chickpea

Farm implements/ tools

Hoshangabad, Narasinghpur, Raisen

- 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 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

Jabalpur

- Dryland weeder

Alternate farming systems

Hoshangabad, Raisen

- **Agro- hortisystem:** Mango + pea/ berseem (green fodder)/ wheat/ chickpea/ soybean
- **Silvi- pastoral system:** Teak + sudan grass
- **Fodder/ green biomass:** *Dichrostachys cineria*, *Albizia amara*, *Faidherbia albida*, *Hardwickia binata*, *Cassia*, *Leucaena leucocephala*, *Albizia lebbeck*
- **Fruits:** Ber, pomegranate, mango, fig, tamarind
- **Medicinal and aromatic plants:** *Withamnia somnifera*, *Rauvolfia serpentina*, *Vetiveria zizanioides*, *Palmarosa*, *Liquoric*.
- **Vegetables:** Chillies, okra, watermelon, cowpea, cluster bean, amaranthus, round melon
- **Animal component:** Male/ female cattle, female buffaloes, sheep, goat

Jabalpur

- **Agro-horti system:** Mango + pea/ berseem (green fodder)/ wheat/ chickpea/ soybean, mango/ guava/ amla + field crops (Wheat, barley, pulses and oilseeds)
- **Silvi-pastoral system:** Teak + sudan grass
- **Fodder/ green biomass:** *Leucaena leucocephala*, *Albizia amara*, *Dichrostachys cineria*, *Melia azadirach*, *Hardwickia binata*, *A.lebbeck*
- **Fruits:** Mango, ber, guava, tamarind, karonda
- **Medicinal and aromatic plants:** *Safed musli*, *Palmarosa*, *Withamnia somnifera*, *Papaver somniferum*, *Vetiveria zizanioides*

- **Vegetables:** Brinjal, chilli, cowpea, okra, bottle gourd, round melon.
- **Animal component:** Female cattle, male cattle, female buffaloes, goats

Narasinghpur

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

Contingent planning

Hoshangabad, Narasinghpur, Raisen

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

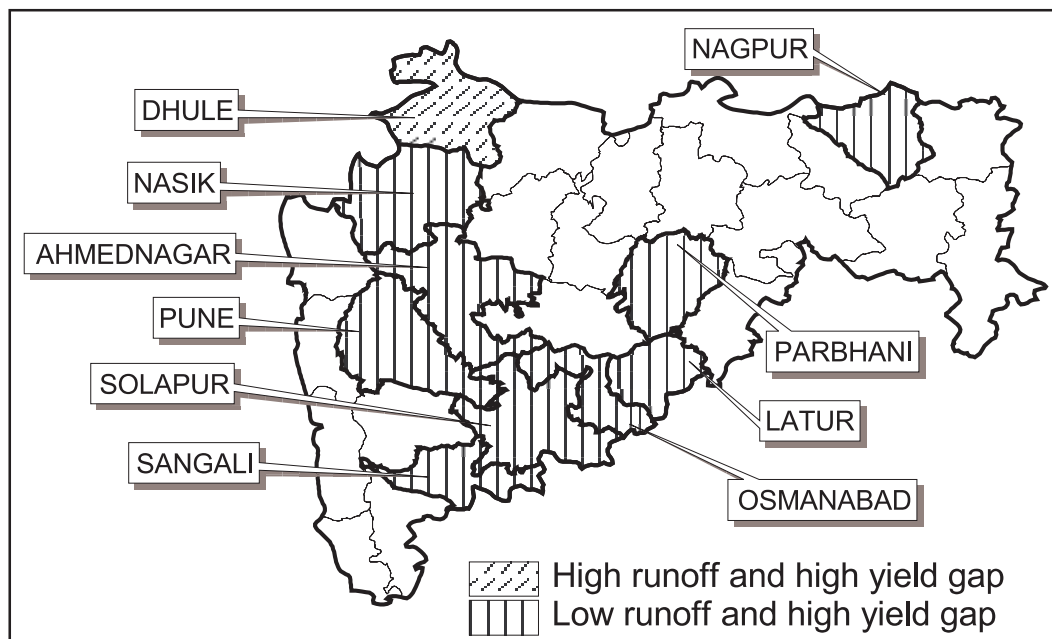
Jabalpur

- **Normal season**
 - Rice

- Very early group - less than 95 days (Prasanna, Vandana, JR 3-45)
- Early group - 95 to 115 days (IR-64, IR 50, Basmati)
- Medium duration - 125 to 145 days (IR-36, Jaya, Kranthi)
- Sorghum (CSH 5, CSH 6, other hybrids)
- Maize (Ganga-1, Ganga 5, other hybrids)
- Pigeonpea (NP (WR) 15)
- Soybean (JS 335)
- Sesame (JT 7)
- Groundnut (Jawahar, Jyothi-1)
- Kodo kutki (J.kodo 136, J. kutki)
- Blackgram (JU 2, DU 4)
- Greengram (K851, JM 45)
- **Intercropping**
 - Sorghum + pigeonpea (2:1)
 - Soybean + pigeonpea (4:1)
- **Late season**
 - Rice - late variety (IR 50, JR 3-45)
 - Kodo (JK 155)
 - Sorghum (CSH 5, other hybrids)
 - Pigeonpea (JA 4, Asha)
 - Groundnut (Exotic 1-1)
 - Blackgram (DU 4)
 - Sesame (JT-1)
 - Safflower (JSF 1)
 - Sunflower (Morden)
- **Late season drought**
 - Harvested rainwater recycled as life saving irrigation
- **Lowland - Direct seeded**
 - Re-sowing of rice is needed if plant population is less than 50%
 - Weeds are uprooted by manual weeding practice
 - Spray of insecticide make sure if attack of insect pest observed
 - Spraying of micronutrient if deficiency is noticed

MAHARASHTRA

In Maharashtra there are ten districts viz. Ahmednagar, Aurangabad, Latur, Nagpur, Nasik, Osmanabad, Parbhani, Pune, Sangli and Solapur with low runoff and high yield gap and one district viz. Dhule with high runoff and high yield gap.



District	Region
Ahmednagar	Low runoff and high yield gap
Aurangabad	
Latur	
Nagpur	
Nasik	
Osmanabad	
Parbhani	
Pune	
Sangli	
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

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

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:** 891mm
- **Potential evapotranspiration:** 1861 mm
- **Moisture availability period:** 120 - 150 days

Nagpur

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

Nasik

- **Climate:** Hot semi arid
- **Physiography:** South Western Maharashtra
- **Soils:** Shallow and medium loamy, medium and deep clayey black soils (Vertic Inceptisols - 85%; Vertisols - 15%)
- **Annual rainfall:** 591mm
- **Potential evapotranspiration:** 1659 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

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

Sangli

- **Climate:** Hot semi arid/ Hot dry sub humid
- **Physiography:** South western Maharashtra
- **Soils:** Shallow and medium loamy, medium and deep clayey black soils, shallow and medium loamy and clayey black soils, deep clayey black soils (Vertic Inceptisols - 75%; Vertisols - 25%)
- **Annual rainfall:** 571 mm
- **Potential evapotranspiration:** 1620 mm
- **Moisture availability period:** 90- 180 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

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

Aurangabad, Latur, Osmanabad, Parbhani

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

Nagpur

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

Nasik

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

Pune

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

Sangli

- Compartment bunding
- Contour bunds
- *In situ* conservation measures like conservation furrows, mulching and deep tillage
- Indigenous water harvesting structures

Crop management

Ahmednagar, Aurangabad, Latur, Nasik, Osmanabad, Parbhani, Pune, Sangli, Solapur

- **Varieties:** Vikas, G-122, Vijay, Vishal, PG 12, Pusa 391
- **Seed rate:** 75 kg/ha
- **Planting pattern:** 30 X 10 cm
- **Nutrient management:** 12.5 kg N + 25 kg P₂O₅/ha
- **Pest management:**
 - Weeding once at 25-30 days from sowing
 - Pod borer management - NPV culture extract of 500 caterpillars in 500 l of water/ ha or Methyl parathion (2% dust) 20 kg/ha or Quinalphos (25 Ec) one litre in 500 l of water per ha
- **Some other important practices**
 - Protects irrigation at branching and pod filling
 - Sowing upto end of October
 - Seed treatment with Thiram/ Captan - 3 g and Rhizobium culture - 25 g

Nagpur

- **Varieties:** ICCV - 2, Pusa 391, GG 1
- **Seed rate:** 80 kg/ha
- **Planting pattern:** 30 X 10 cm
- **Nutrient management:** 20 kg N + 40 kg P₂O₅/ha
- **Pest management:** Pod borers cause maximum damage. For controlling pod borer spray of 250 ml Dimecron or 1.5 l of Thiodon in 1000 l of water/ ha at the time of flowering and at pod formation is recommended
- **Some other important practices:** Seed inoculation with Rhizobium

Suitable cropping systems

Ahmednagar, Aurangabad, Latur, Nasik, Osmanabad, Parbhani, Pune, Sangli, Solapur

- Sorghum (*rabi*) - chickpea
- Sorghum (*rabi*)/ safflower (*rabi*)/ sunflower (*rabi*) - chickpea (*rabi*)
- Pearl millet - chickpea
- Greengram/ sunflower - chickpea

Nagpur

- Soybean (JS 335) - chickpea (ICCV2)
- Sorghum (CSH - 1, other hybrids) - chickpea (Chaffa)

Farm implements/ tools

Ahmednagar, Latur, Nasik, Osmanabad, Parbhani, Pune, Sangli, 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 compartment bunding. Rs. 1050/-
- Baliram plough: Identified for moisture conservation practices like ridges and furrows and compartment bunding. Rs. 2500/-
- Kopergaon bullock drawn two bowl seed drill: The local made seed drill named "Kopergaon seed drill" is operated on the field for sowing crops like sorghum, pearl millet, pigeonpea etc. and identified for sowing of the crops of dryland region. Rs. 9000/-

Aurangabad

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

Nagpur

- 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.

Alternate farming systems

Aurangabad

- **Fodder/ green biomass:** *Stylosanthes* sole and stylo-marvel pastoral system recorded higher green fodder yield than sole or combination of grasses. *Leucaena leucocephala*, *Albizia lebbeck*, *Dalbergia sissoo*, *Acacia indica*, *Acacia procera*, *Gliricidia*
- **Fruits:** 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*, *Palmarosa*, *Vetiveria zizanioides*, *Ocimum viride*
- **Vegetables:** Onion, chilli, brinjal, okra, amaranthus, bottle gourd
- **Animal Component:** Female cattle, male cattle, female buffaloes, goat, poultry

Nasik, Osmanabad, Sangli

- **Silvipasture:** *Leucaena* + marvel-8
- **Alley cropping:** Ber (20 m alleys) + pearl millet + pigeonpea for shallow soils
- **Fodder:** Maize (African Tall), Oats (Kent), *Stylo hamata*
- **Fodder/ green biomass:** *Dalbergia sissoo*, *Albizia lebbbeck*, *Anogeissus latifolia*, *Sesbania*, *Stylosanthes*, *Marvel - 8 grass*
- **Fruits:** Ber, custard apple, pomegranate, amla + *kharif* spreading crops
- **Medicinal and Aromatic Plants:** *Catharanthus roseus*, *Palmarosa*, *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

Nagpur

- **Fodder/ green biomass:** *Leucaena leucocephala*, *Albizia lebbbeck*, *Dalbergia sissoo*, *Acacia indica*, *Acacia procera*, *Gliricidia*
- **Fruits:** Pomegranate, ber, mango, sapota, guava, tamarind
- **Medicinal and aromatic plants:** *Solanum viarum*, *Catharanthus roseus*, *Palmarosa*, *Vetiveria zizanioides*, *Ocimum viride*, Saphed Musli.
- **Vegetables:** Onion, chilli, brinjal, okra, amaranthus, bottle gourd
- **Animal Component:** Male/ female cattle, female buffaloes, sheep, goat, poultry

Ahmednagar, Latur, Parbhani, Pune, Solapur

- **Agri-horti system** - Ber (5x5 m) + mothbean (8 lines) (30 x 10 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*, *Albizia lebbbeck*, *Dalbergia sissoo*, Neem, *Prosopis cineraria*
- **Fruits:** 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

Ahmednagar, Aurangabad, Osmanabad

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

Latur, Pune, Solapur

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

Nasik, Sangli

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

Contingent planning

Ahmednagar, Aurangabad, Latur, Nasik, Osmanabad, Parbhani, Pune, Sangli, Solapur

- **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

Nagpur

- **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. 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, chickpea are not able to sustain such stress. Therefore, use of some conditioner such as spray of urea, not exceeding to 2 per cent concentration, may be useful.
 - If there is a total failure of crop, sowing of photo-insensitive crops such as 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, to follow *rabi* crop safflower (N.7), pigeonpea (C.11) in September.
- **Extended monsoon**
 - Advantage of this situation is exploited for double cropping with safflower and chickpea. Safflower (No.7) may be sown after sorghum till 15th October. Beyond 15th October chickpea may be sown.

District	Region
Dhule	High runoff and high yield gap

Agro-geographic setting

Dhule

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

Soil and water conservation

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

Crop management

- **Varieties:** Vikas, Vijay, Vishal and Pusa 391
- **Seed rate:** 75 kg/ha
- **Planting pattern:** 30 X 10 cm

- **Nutrient management:** 12.5 kg N + 25 kg P₂O₅/ha
- **Pest management:**
 - Weeding once at 25-30 days from sowing
 - Pod borer management - NPV culture extract of 500 caterpillars in 500 l of water/ ha or Methyl parathion (2% dust) 20 kg/ha or Quinalphos (25 Ec) one litre in 500 l of water per ha
- **Some other important practices**
 - Protects irrigation at branching and pod filling
 - Sowing upto end of October
 - Seed treatment with Thiram/ Captan - 3 g and Rhizobium culture - 25 g

Suitable cropping systems

- Sorghum (*rabi*) - chickpea
- Sorghum (*rabi*)/ safflower (*rabi*)/ sunflower (*rabi*) - chickpea (*rabi*)
- Pearl millet - chickpea
- Greengram/ sunflower - chickpea

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 compartment bunding. Rs.1050/-
- Baliram plough: Identified for moisture conservation practices like ridges and furrows and compartment bunding. Rs.2500/-
- Kopergaon bullock drawn two bowl seed drill: The local made seed drill named "Kopergaon seed drill" is operated on the field for sowing crops like sorghum, pearl millet, pigeonpea etc. and identified for sowing of the crops of dryland region. Rs.9000/-

Alternate farming systems

- **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*, *Albizia lebbeck*, *Anogeissus latifolia*, *Sesbania Stylo*, *Marvel - 8 grass*
- **Fruits:** Ber, custard apple, pomegranate, amla + *kharif* spreading crops
- **Medicinal and Aromatic Plants:** *Catharanthus roseus*, *Palmarosa*, *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 systems

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

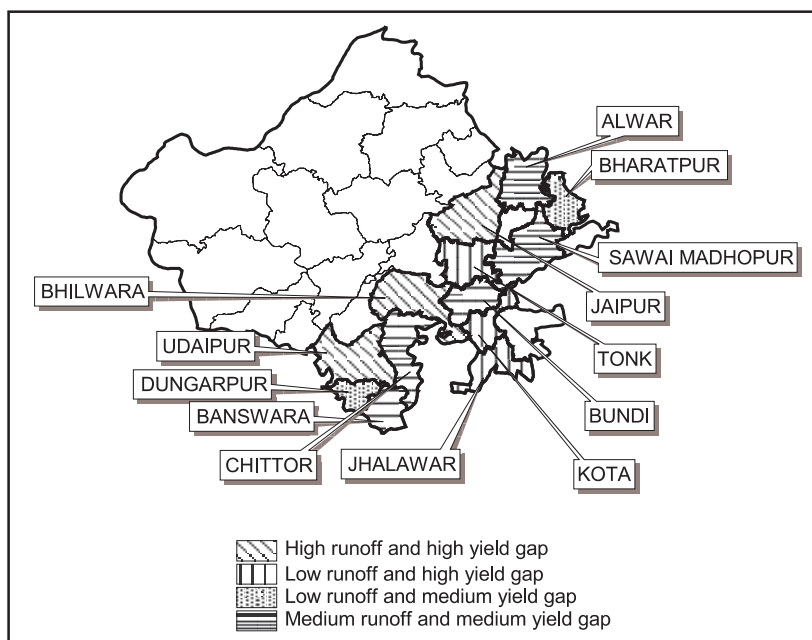
Contingent planning

- **Second fortnight of June:**
 - All *Kharif* crops
- **First fortnight of July:**
 - Pearl millet, setaria, groundnut, castor, pigeonpea, horsegram
 - Intercropping
 - 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

RAJASTHAN

In Rajasthan, Alwar, Bhanswara, Bundi, Chittorgarh and Sawaimadhapur are with medium runoff and medium yield gap, Bharatpur and Dungarpur are with low runoff and medium yield gap, Bhilwara, Jaipur and Udaipur are with high runoff and high yield gap, and Jhalawar, Kota and Tonk are under low runoff and high yield gap.



District	Region
Alwar	Medium runoff and medium yield gap
Bhanswara	
Bundi	
Chittorgarh	
Sawaimadhapur	

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

Bhanswara

- **Climate:** Hot moist semi arid
- **Physiography:** Western Malwa Plateau

- **Soils:** Deep clayey black soils, shallow black soils (Vertic Inceptisols - 100%)
- **Annual rainfall:** 938 mm
- **Potential evapotranspiration:** 1512 mm
- **Moisture availability period:** 120 - 150 days

Bundi

- **Climate:** Hot dry semi arid/ 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

Chittorgarh

- **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

Sawaimadhopur

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

Soil and water conservation

Alwar

- Compartment 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

Bhanswara

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

Bundi, Chittorgarh, Sawaimadhopur

- 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

Alwar

- **Varieties:** BG 256, Gaurav, Samrat, RSG 888 and K 850
- **Seed rate:** 70 - 75 kg/ha
- **Planting pattern:** 30 x 10 cm
- **Nutrient management:** 10-15 kg N + 60 P₂O₅ kg/ha. Full dose of N and P₂O₅ as basal at 10 cm depth
- **Pest management**
 - Aphids and pod borer
 - Spray with systemic insecticide i.e., Endosulphan 35 E.C.

Bhanswara

- **Varieties:** BG-209, C-235, Dohad Yellow, BG-203, RSG-2 and RSG-44
- **Seed rate:** 80 kg/ha
- **Planting pattern:** 30 cm rows
- **Integrated Nutrient management:** 15 kg N + 30 kg P₂O₅ + 20 Kg S / ha. All nutrients should be drilled at sowing.

Bundi

- **Varieties:** C-235, Dohad Yellow, RSG-2 RSG-44, RSG 888, DCP 923
- **Seed rate:** 80 kg/ha
- **Planting Pattern:** 30 cm rows
- **Nutrient management:** 15 kg N + 30 kg P₂O₅ + 20 kg S/ha. All N and P should be drilled at sowing

Chittorgarh

- **Varieties:** BG-209, C-235, Dohad Yellow, BG-203, RSG-2, and RSG-44
- **Seed rate:** 80 kg/ha
- **Planting pattern:** 30 cm rows
- **Nutrient management:** 15 kg N + 30 kg P₂O₅ + 20 kg S/ha. All nutrients should be drilled at sowing.

Sawaimadhopur

- **Varieties:** C-235, Dohad Yellow, RSG-2 , RSG-44, RSG 888
- **Seed rate:** 80 kg/ha
- **Planting Pattern:** 30 cm rows
- **Nutrient Management:** 15 kg N + 30 kg P₂O₅ + 20 kg S/ha. All nutrients should be drilled at sowing.

Some other important practices

Alwar

- Seed treatment with rhizobium culture
- Sowing - First fortnight of October

Bhanswara, Bundi, Chittorgarh, Sawaimadhopur,

- Sowing in last week of September
- Most suitable crop for growing in tank beds on conserved soil moisture

Suitable cropping systems

Alwar

- Pearl millet + cowpea (fodder) - chickpea + rapeseed mustard

Bhanswara, Bundi, Chittorgarh, Sawaimadhopur

- Chickpea + safflower (6:1) row ratio at 30 cm spacing
- Chickpea + rapeseed mustard - 4:1 row ratio at 30 cm spacing

Farm implements/ tools

Alwar

- Shivaji seed cum fertilizer drill

Bundi

- Arjia Pora
- Multipurpose Tool bar
- Dry land weeder

Chittorgarh

- Two bowl seed cum fertilizer drill

Alternate farming systems

Alwar, Bundi, Chittorgarh, Sawaimadhopur

- **Marginal lands**
 - **Silviculture** (Land capability class I): *Acacia tortilis*
 - **Alley cropping:** (Land capability class II): *Jatropha spp* + greengram
 - **Silvipastoral system** (Land capability class III): *Prosopis cineraria* + *Cenchrus spp*
 - **Horti-pastoral system:** Ber + *cenchrus setigerus*
 - **Fodder/Green biomass:** *Alianthus excelsa*, *Albizia lebbbeck*, *Dalbergia sissoo*, neem, *Prosopis cineraria*
 - **Fruits:** 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 cattle, male cattle, female buffaloes, sheep, goats

Bhanswara

- **Fodder/ green biomass:** The farmers growing ber (10x6m) on light textured soils are advised to take inter crop of either greengram or sorghum (fodder) *A.lebbbeck*, *A. indica*, *A albida*, *Cassia siamia*, *D.sissoo*, *Alianthes excelsa*
- **Fruits:** Mango, pomegranate, guava, ber, fig, jamun
- **Medicinal & Aromatic Plants:** *Plantago ovata*, *Cassia angustifolia*, *Liquorice*
- **Vegetables:** Drumstick, cluster bean, cowpea, long melon, okra
- **Animal component:** Female cattle, male cattle, female buffaloes, goats

Contingent planning

Alwar, Bundi, Chittorgargarh, Sawaimadhopur

- **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.

Bhanswara

- **Normal sowing (Early July)**
 - Castor (GCH-4, GCH-5, GCH-6, other hybrids)

- Pearl millet (GHB-235, GHB-316)
- Cowpea (Guj. Cowpea-4)
- Clusterbean (Guj. Clusterbean-1)
- Greengram (Guj. Mung-4)
- Sorghum (GSF-4)
- Mothbean (Guj.1)
- Karingado (Guj. Karingado-1)
- **Delayed sowing (15th July to early August)**
 - Castor (GCH-4, other hybrids)
 - Sorghum (GSF-4)
 - Cluster bean (Guj. Clusterbean-1)
- **Very delayed sowing (mid August)**
 - Castor (GCH-4, other hybrids)

District	Region
Bhilwara Jaipur Udaipur	High runoff and high yield gap

Agro-geographic Setting

Bhilwara

- **Climate:** Hot dry semi arid
- **Physiography:** East Rajasthan Uplands (Aravelli hills)
- **Soils:** Deep loamy grey brown and alluvium - derived soils (Vertic Inceptisols - 100%)
- **Annual rainfall:** 658 mm
- **Potential evapotranspiration:** 1559 mm
- **Moisture availability period:** 90 - 120 days

Jaipur

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

Udaipur

- **Climate:** Hot dry semi arid
- **Physiography:** East Rajasthan Uplands/ Plains

- **Soils:** Deep loamy grey brown and alluvium - derived soils (Psaments - 30%; Vertic Inceptisols -70%)
- **Annual rainfall:** 661 mm
- **Potential evapotranspiration:** 1380 mm
- **Moisture availability period:** 90 - 120 days

Soil and water conservation

Bhilwara, Jaipur, Udaipur

- 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

Bhilwara

- **Varieties:** BG-209, C-235, Dohad Yellow, BG-203, RSG-2 and RSG-44
- **Seed rate:** 80 kg/ha
- **Planting Pattern:** 30 cm rows
- **Nutrient management:** 15 kg N + 30 kg P₂O₅ + 20 kg S/ha. All N and P should be drilled at sowing.

Jaipur, Udaipur

- **Varieties:** C-235, Dohad Yellow, RSG-2, RSG-44, RSG 888
- **Seed rate:** 80 kg/ha
- **Planting pattern:** 30 cm rows
- **Nutrient management:** 15 kg N + 30 kg P₂O₅ + 20 kg S/ha. All nutrients should be drilled at sowing.

Some other important practices

Bhilwara, Jaipur, Udaipur

- Sowing in last week of September
- Most suitable crop for growing in tank beds on conserved soil moisture

Suitable cropping systems

Bhilwara, Jaipur, Udaipur

- Chickpea + safflower (6:1) row ratio at 30 cm spacing
- Chickpea + rapeseed mustard - 4:1 row ratio at 30 cm spacing

Farm implements/ tools

Bhilwara

- Arjia Pora: Placement of seed and fertilizer at proper depth. Rs.100/-
- Multipurpose Tool bar: Ridge making, interculture, blade harrowing and seed and fertilizer drilling. Rs.2000/-
- Seeding attachment for ridge sowing: Ridge sowing of maize. Rs.300/-
- Dry land weeder: Intercultural operations. Rs.500/-
- Rotavator-L-Series: The operations like ploughing, harrowing, clod crushing, leveling are done simultaneously. Rs.60000/-
- Two row seed drill: Two row sowing at a time. Rs.1500/-
- Plough planter: Placement of seed. Rs.1500/-
- Post hold digger: Digging of pits for planting tree species. Rs.40000/-

Alternate farming systems

Bhilwara, Jaipur, Udaipur

- **Marginal lands**
 - **Silviculture** (Land capability class LCC V): *Acacia tortilis*
 - **Alley cropping**: (Land capability class LCC III): *Jatropha spp* + greengram
 - **Silvipastoral system** (Land capability class LCC IV): *Prosopis cineraria* + *Cenchrus spp*
 - **Horti - pastoral system**: Ber + *cenchrus setigerus*
 - **Fodder/ Green biomass**: *Alianthus excelsa*, *Albizia lebbbeck*, *Dalbergia sissoo*, *Azadirachta indica*, *Prosopis cineraria*, *Dichrostachys*
 - **Fruits**: 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 cattle, male cattle, female buffaloes, sheep, goats

Contingent planning

Bhilwara, Jaipur, Udaipur

- Good and normal rainfall
- Grow large areas under improved varieties of cereals, pulses and oilseeds during *kharif* on heavy soils, conserved 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.

District	Region
	Bharatpur Dungarpur
Low runoff and medium yield gap	

Agro-geographic setting

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

Dungarpur

- **Climate:** Hot dry semi arid
- **Physiography:** Rajasthan uplands
- **Soils:** Deep loamy grey brown and alluvium - derived soils (Vertic Inceptisols - 100%)
- **Annual rainfall:** 715 mm
- **Potential evapotranspiration:** 1503 mm
- **Moisture availability period:** 120-150 days

Soil and water conservation

Bharatpur

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

Dungarpur

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

Crop management

Bharatpur

- **Varieties:** C 235, Dohad Yellow, RSG-2 RSG-44, RSG 888, Samrat

- **Seed rate:** 80 kg/ha
- **Planting pattern:** 30 cm rows
- **Integrated Nutrient management:** 15 kg N + 30 kg P₂O₅/ha. All N and P should be drilled at sowing

Dungarpur

- **Varieties:** C-235, Dohad Yellow, RSG-2, RSG-44, RSG 888
- **Seed rate:** 80 kg/ha
- **Planting pattern:** 30 cm rows
- **Nutrient management:** 15 kg N + 30 kg P₂O₅ + 20 kg S/ha. All nutrients should be drilled at sowing

Some other important practices

Bharatpur, Dungarpur

- Sowing in last week of September
- Most suitable crop for growing in tank beds on conserved soil moisture

Suitable cropping systems

Bharatpur, Dungarpur

- Chickpea + safflower (6:1) row ratio at 30 cm spacing
- Chickpea + rapeseed mustard - 4:1 row ratio at 30 cm spacing

Farm Implements/ Tools:

Bharatpur

- Shivaji seed cum fertilizer drill

Alternate farming systems

Bharatpur

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

Dungarpur

- **Fodder/ green biomass:** The farmers growing ber (10 x 6m) on light textured soils are advised to take inter crop of either greengram or sorghum (fodder)
- *A.lebbeck*, *A. indica*, *A albida*, *Cassia siamia*, *D.sissoo*, *Ailanthus excelsa*
- **Fruits:** Mango, pomegranate, guava, ber, fig, jamun

- **Medicinal & Aromatic Plants:** *Plantago ovata*, *Cassia angustifolia*, *Liquorice*
- **Vegetables:** Drumstick, cluster bean, cowpea, long melon, okra
- **Animal Component:** Female cattle, male cattle, female buffaloes, goats

Contingent planning

Bharatpur

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, Pusa 992) blackgram (T-9) and greengram (samrat, pant M 5). 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.

Dungarpur

- **Normal sowing (early July)**
 - Castor (GCH-4, GCH-5, GCH-6, other hybrids)
 - Pearl millet (GHB-235, GHB-316)
 - Cowpea (Guj. Cowpea-4)
 - Clusterbean (Guj. Clusterbean-1)
 - Greengram (Guj. Mung-4)
 - Sorghum (GSF-4)
 - Mothbean (Guj.1)
 - Karingado (Guj. Karingado-1)
- **Delayed sowing (15th July to early August)**
 - Castor (GCH-4, other hybrids)
 - Sorghum (GSF-4)
 - Cluster bean (Guj. Clusterbean-1)

- **Very delayed sowing (mid August)**

- Castor (GCH-4)

District	Region
Jhalawar Kota Tonk	Low runoff and high yield gap

Agro-geographic Setting

Jhalawar

- **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

Kota

- **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

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

Jhalawar

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

Kota, 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 intervals

Crop management

Jhalawar, Kota, Tonk

- **Varieties:** C-235, Dohad Yellow, RSG-2, RSG-44, Samrat
- **Seed rate:** 80 kg/ha
- **Planting pattern:** 30 cm rows
- **Nutrient management:** 15 kg N + 30 kg P₂O₅ + 20 kg S/ha. All nutrients should be drilled at sowing.

Some other important practices

Jhalawar, Kota, Tonk

- Sowing in last week of September
- Most suitable crop for growing in tank beds on conserved soil moisture

Suitable cropping systems

Jhalawar, Kota, Tonk

- Chickpea + safflower (6:1) row ratio at 30 cm spacing
- Chickpea + rapeseed mustard - 4:1 row ratio at 30 cm spacing

Farm implements

Jhalawar

- Two bowl seed cum fertilizer drill

Alternate farming systems

Jhalawar, Kota

- **Fodder/ green biomass:** *Ailanthus excelsa*, *A.lebbeck*, *D.sissoo*, *A.indica*, *P.cineraria*, *Dichrostachys*
- **Fruits:** Ber, date palm, jamun, phalsa, karonda
- **Medicinal/ Aromatic Plants:** *Plantago ovata*, *Cassia angustifolia*, *Safed musli*, *Papaver somniferum*

- **Vegetables:** Clusterbean, cowpea, amaranthus, round melon, long melon
- **Animal Component:** Female cattle, male cattle, female buffaloes, sheep, goats

Tonk

Marginal lands

- **Silviculture** (Land capability class): *Acacia tortilis*
- **Alley cropping:** (Land capability class): *Jatropha spp* + greengram
- **Silvipastoral system** (Land capability class): *Prosopis cineraria* + *Cenchrus spp*
- **Horti -pastoral system:** Ber + *cenchrus setigerus*
- **Fodder/ Green biomass:** *Alianthus excelsa*, *Albizia lebbeck*, *Dalbergia sissoo*, neem, *Prosopis cineraria*
- **Fruits:** 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 buffaloes, sheep, goats

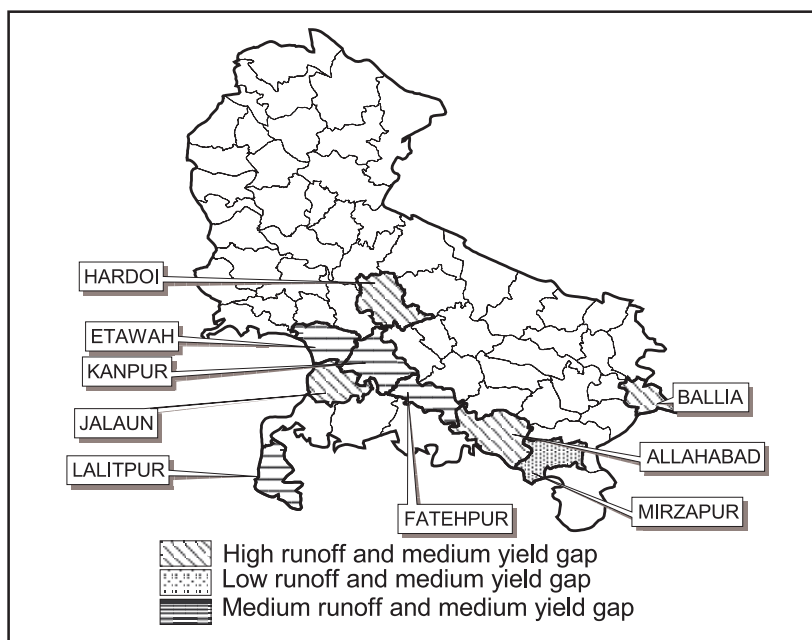
Contingent crop planning

Jhalawar, Kota, Tonk

- **Good and normal rainfall**
 - Grow large areas under improved varieties of cereals, pulses and oilseeds during *kharif* on heavy soils, conserved 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, four districts viz., Allahabad, Ballia, Hardoi and Jalaun are with high runoff and medium yield gap, five districts viz., Etawah, Fatehpur, Kanpur (Rural), Kanpur (Urban) and Lalitpur are with medium runoff and medium yield gap and one district viz., Mirzapur is with low runoff and medium yield gap.



District	Region
Allahabad Ballia Hardoi Jalaun	High runoff and medium yield gap

Agro-geographic setting

Allahabad

- **Climate:** Hot moist semi arid
- **Physiography:** Ganga - Yamuna Doab (Northern plains)
- **Soils:** Deep loamy alluvium - derived soils (Inceptisols - 100%)
- **Annual rainfall:** 1027 mm
- **Potential evapotranspiration:** 1537 mm
- **Moisture availability period:** 120 - 150 days

Ballia

- **Climate:** Hot moist/ dry sub humid
- **Physiography:** Aradh plains (Northern plains)

- **Soils:** Deep loamy alluvium derived soils, deep, loamy alluvium - derived soils (Inceptisols - 100%)
- **Annual rainfall:** 1085 mm
- **Potential evapotranspiration:** 1492 mm
- **Moisture availability period:** 150 - 210 days

Hardoi

- **Climate:** Hot dry sub humid/ hot moist semi arid
- **Physiography:** Ganga - Yamuna Doab
- **Soils:** Deep loamy alluvium derived soils (Inceptisols - 100%)
- **Annual rainfall:** 1062 mm
- **Potential evapotranspiration:** 1494 mm
- **Moisture availability period:** 150 - 180/ 120- 150 days

Jalaun

- **Climate:** Hot moist semi arid
- **Physiography:** Central South Uttar Pradesh
- **Soils:** Deep loamy alluvium derived soils, deep, loamy alluvium - derived soils (Inceptisols - 100%)
- **Annual rainfall:** 1045 mm
- **Potential evapotranspiration:** 1602 mm
- **Moisture availability period:** 120- 150 days

Soil and water conservation

Allahabad, Jalaun

- Deep tillage during summer facilitates better rainwater intake, weed control, timely sowing of rainy season crops and enhanced grain biomass.
- Open end contour or graded bunds (0.3-4%) were found convenient and beneficial in Vindhyan tract for better conservation of rainwater and safe disposal of surface water
- Farm ponds/storage bundhies in mild to flat topo sequence of gangetic plains and foot hills of Vindhyan range hold promise for increased production through intensifying runoff farming and conservation farming practices
- Drop structures at intervals across seasonal rivulets in Vindhyan tract (with rolling/abrupt / dissected topography) and wide diameter wells hold promise as additional minor irrigation source and increased productivity
- Supplemental irrigation utilizing harvested water for negating adverse effect of late season drought by increasing production of rice by 25-30 per cent

Hardoi

- Sowing across the slope and ridging later
- Compartment bunds for raising crops on conserved soil moisture
- Contour farming
- Deep ploughing during summer followed by two cultivators

Ballia

- Inter-plot water harvesting
- Raised bed and sunken system

Crop management

Allahabad

- **Varieties:** K- 850, Radhey, Avrodhi, BG 206, Pant G 186
- **Seed rate:** 80 kg/ha
- **Nutrient management:** 20 Kg N+40 kg P₂O₅/ha. Place fertilizer 10 - 15 cm deep in seed furrows.
- **Integrated pest management**
 - Pod borers cause maximum damage. For controlling pod borer spray of 250 ml Dimecron or 1.5 l of Thiodin in 1000 l of water/ha at the time of flowering and at pod formation is recommended

Ballia

- **Varieties:** KWR 108, K 850, K850, Pusa 372
- **Seed rate:** 80 kg/ha
- **Planting Pattern:** 30 cm
- **Nutrient management:** 20 kg N + 40 kg P₂O₅ + 20 kg K₂O + 20 kg S/ha. Place fertilizer 10 - 15 cm deep in the seed furrows.
- **Pest management**
 - Pod borers cause maximum damage. For controlling pod borer spray of 50 ml Dimecron or 1.5 l. Thiodon in 1000 l of water/ha at the time of flowering and at pod formation is recommended

Hardoi

- **Varieties:** K- 850, Radhey, Avrodhi, BG 206, Pant G 186
- **Seed rate:** 80 kg/ha
- **Nutrient management:** 20 Kg N+40 kg P₂O₅/ha. Place fertilizer 10 - 15 cm deep in seed furrows.
- **Integrated pest management**
 - Pod borers cause maximum damage. For controlling pod borer spray of 250 ml Dimecron or 1.5 l of Thiodin in 1000 l of water/ha at the time of flowering and at pod formation is recommended

Jalaun

- **Varieties:** Radhey and Avrodhi, JG 74, JG 315, BG 256
- **Seed rate:** 80 kg/ha
- **Nutrient Management:** 20 kg N + 40 kg P₂O₅ + 20 kg K₂O + 20 kg S / ha
- **Pest management**
 - Pod borers cause maximum damage. For controlling pod borer spray of 250 ml Dimecron or 1.5 l of Thiodin in 1000 l of water/ha at the time of flowering and at pod formation is recommended
- **Some other important practices:** Seed inoculation with Rhizobium

Suitable cropping systems

Allahabad

- Rice - chickpea
- Linseed + chickpea
- Sesamum + chickpea

Ballia

- Maize - chickpea
- Chickpea + rapeseed mustard (4:1)
- Pearlmillet - chickpea
- Chickpea + barley (3:1)
- Chickpea + linseed (3:1)
- Sesamum - chickpea
- Blackgram - chickpea

Hardoi

- Rice - chickpea
- Linseed + chickpea
- Sesamum + chickpea

Jalaun

- Chickpea + linseed
- Sorghum (Fodder) + chickpea
- Barley + chickpea (2:1)
- Chickpea + mustard(4:1)

Farm Implements/ Tools

Allahabad, Hardoi

- Land preparation and sowing of seed and application of fertilizer by power tiller operated till plant machine

Ballia, Jalaun

- Bullock drawn Malviya multi - farming machine: For field preparation, for seeding dryland crops and fertilizing through mechanical metering device, for intercultivation between two plant rows (particularly *Kharif* season crop) (Rs.2350 per unit)
- Dryland weeder (modified from of weeder supplied by T.A.U): For weed control between plant rows of rainfed crops (Rs.70 per unit)

Alternate farming systems

Allahabad, Hardoi

- **Fodder/ green biomass:** *Leucaena*, *D. sissoo*, *Azadirachta indica*, *Syzygium cumini*, *Sesbania*, *Pongamia*, *Cassia siamea*

- **Fruits:** Mango, guava, amla, ber, phalsa, bel, jamun.
- **Medicinal/ Aromatic Plants:** *Papaver somniferum*, *Palmarosa*, *Vetiveria zizanioides*, *Cymbopogon flexuosus*
- **Vegetables:** Tomato, brinjal, okra, chilli, amaranthus
- **Animal Component:** Female cattle, male cattle, female buffaloes, sheep, goats, poultry

Ballia

- **Agro-horti system:** Ber + wheat, Gauva + wheat, Gauva + pigeonpea, Guava + pea
- **Fodder/green biomass:** *Leucaena leucocephala*, *Azadirachta indica*, *Albizia lebbeck*, *Bauhinia purpurea*, *A. procera*, *B.monosperma*, *A.amara*, *D.sissoo*
- **Fruits:** Guava, amla, ber, mango bael, jamun.
- **Medicinal and aromatic plants:** *Papaver somniferum*, *Cymbopogon flexuosus*, *P. rosalea*, *Palmarosa*, *Vetiveria zizanioides*
- **Vegetables:** Bottle gourd, brinjal, chillies, cluster bean, cowpea, round melon
- **Animal component:** Female and male cattle, female buffaloes, sheep, goat, poultry
- **Fodder/ green biomass:** *Leucaena*, *D. sissoo*, *Azadirachta indica*, *Syzygium cumini*, *Sesbania*, *Pongamia*, *Cassia siamea*
- **Fruits:** Mango, guava, amla, ber, phalsa, bel, jamun.
- **Medicinal/ Aromatic Plants:** *Papaver somniferum*, *Palmarosa*, *Vetiveria zizanioides*, *Cymbopogon flexuosus*
- **Vegetables:** Tomato, brinjal, okra, chilli, amaranthus
- **Animal Component:** Female cattle, male cattle, female buffaloes, sheep, goats, poultry

Jalaun

- **Agro + Horti System:** Guava + pigeonpea /field pea was productive
 - Ber + wheat gave an additional benefit of 59 per cent over sole ber plantation
- Rajmash, a high value crop when associated with barley as an inter crop and supplementing with 3 cm irrigation 30 days after sowing is highly productive

Contingent Planning

Allahabad, Ballia, Hardoi, Jalaun

- **Normal Season**

Kharif

- Rice (NDR-97, NDR-118, Baranideep, NDR 359,[Pant Dhan12, Vandana)
- Maize (Ganga Safed 2, MAR 359, Jaunpuri, Tipakhiya, other hybrids)
- Sorghum (PKV-400, Varsha, other hybrids)
- Pearl millet (BJ104,Pusa 123, Pusa 322, Manupur, WCC-75)
- Pigeonpea (UPAS-120, Bahar, NA 1, Malviya Arhar 13)
- Blackgram (T-9, Narendra Blackgram-1, Pant U 19)
- Greengram (Narendra Moong-1, Pant mung 2, Samrat)
- Sesame (T4, T12, Gujarat Til-1)

Rabi

- Chickpea (Avrodhi, T-3, KWR 108, DCP 92-3)
- Lentil (Pant I-406, Pant L-639, K75, Sheri, NDL-2, DPL-15, Pant G 406)
- Rapeseed mustard (Vibhav, Vardhan, Varuna)
- Linseed (Garima, Sweta)
- Barley (DL-3, Jyothi, Lakhan, Narendra Jau-4)
- Compatible Genotypes for cropping system:
- Sequence (Rice - Lentil NDR-97 - NDL-1)
- Intercropping (Linseed (Sweta) + Chickpea (Avrodhi))
- **Normal onset of monsoon followed by long gaps in rainfall**
 - In case of very early break in monsoon i.e. 7-10 days after seeding and if seedlings are killed resow with the same variety.
 - Gap filling/ transplanting in case of cereals like uplands rice and pearl millet may be done if drought occurs about a month after seeding and is followed by showers. Follow this by light top dressing i.e. 10-15 kg N/ha. For this purpose community nurseries of emergency nurseries should be kept ready.
- **Delayed onset of monsoon**
 - If monsoon sets in as late as the last week of July, short duration uplands
 - Rice such as Narendra-118 and Baranideep are recommended if the rains are delayed beyond the period but start somewhere in the first week of second week of August and growing season is reduced to 60-70 days, then the cultivation of pearl millet (WCC-75, Mannpur), blackgram (Narendra Blackgram-1) and greengram (Pant Moong-1) should be taken up. Yet another alternative could be to harvest a fodder of sorghum, pearl millet, maize or a mixture of either of cowpea, blackgram, and greengram one of the above fodder crops. These crops will be followed by *rabi* crops like chickpea, rapeseed mustard and barley.
- **Early stoppage of rains towards the end of season**
 - Normal sowing of short duration *kharif* crops such as upland rice (N-97, Mutmuri), blackgram (T-9), sesamum (T-13) may be done. Sorghum, maize, pearl millet and cowpea for fodder could be harvested. If the rain stops very early, i.e. by the end of August or first week of September, only fodder crops and grain legumes could be harvested. Later on as a mid-season correction sunflower could be planted as it could be planted as it could be sown any time in the year.
 - Depending on the soil moisture condition, relay sowing of *rabi* crops such as chickpea, lentil, linseed and barley could be done in the *rabi* season.
- **In extreme drought conditions**
 - Only short duration crops like grain legumes (black and greengram) should be grown.
 - Among cereals, maize (Tipekhiya) gave a fair performance
 - Intercropping maize in interrows of pigeonpea was found successful
 - Rice crop, if already sown is not likely to succeed, may be ploughed under to conserve the moisture in the soil. This may permit growing of chickpea, rapeseed mustard or barley during *rabi*.

District	Region
Etawah Fatehpur Kanpur (Rural) Kanpur (Urban) Lalitpur	Medium runoff and medium yield gap

Agro-geographic setting

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

Fatehpur

- **Climate:** Hot moist semi arid
- **Physiography:** Ganga - Yamuna Doab (Norther plains)
- **Soils:** Deep loamy alluvium - derived soils (Inceptisols - 100%)
- **Annual rainfall:** 885 mm
- **Potential evapotranspiration:** 1464 mm
- **Moisture availability period:** 120 - 150 days

Kanpur (Rural), 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:** 120-150 days

Lalitpur

- **Climate:** Hot moist semi arid
- **Physiography:** Bundel Khand Uplands
- **Soils:** Deep loamy and clayey mixed red and black soils (Inceptisols - 100%)
- **Annual rainfall:** 804 mm
- **Potential evapotranspiration:** 1489 mm
- **Moisture availability period:** 120 - 150 days

Soil and water conservation

Etawah

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

Fatehpur

- Sowing across the slope and ridging later
- Compartment 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

Kanpur (Rural), Kanpur (Urban), Lalitpur

- Sowing across the slope and ridging later
- Compartment bunds for raising crops on conserved soil moisture
- Contour farming
- Deep ploughing during summer followed by two cultivators

Crop management

Etawah

- **Varieties:** Radhey , Avrodhi, BG 256, DCP 92-3, JG 315
- **Seed rate:** 80 kg/ha
- **Nutrient Management:** 15 kg N+ 40 kg P₂O₅ + 20 kg K₂O + 20 kg S/ha. Place fertilizer 10-15 cm deep in seed furrows.
- **Pest management**
 - Pod borers cause maximum damage. IPM package should be followed, spray 5 % NSKE with need based chemicals 250 ml Dimecron or 1.5 l of Thiodin in 1000 l of water/ha at the time of flowering and pod formation.
- **Some other important practices**
 - Seed inoculation with Rhizobium

Fatehpur

- **Varieties:** Radhey, Avrodhi, KWR 108, DCP 92-3, BG 256.
- **Seed rate:** 80 kg/ha
- **Pest management**
 - Pod borers cause maximum damage. For controlling pod borer spray of 250 ml Dimecron or 1.5 l of Thiodin in 1000 litres of water/ha at the time of flowering and at pod formation is recommended

- **Some other important practices**

- Seed inoculation with Rhizobium

Kanpur (Rural), Kanpur (Urban)

- **Varieties:** K- 850, Radhey, Avrodhi, JG 315, JG 74, KWR 108
- **Seed rate:** 80 kg/ha
- **Nutrient management:** 20 Kg N + 40 kg P₂O₅/ha. Place fertilizer 10 - 15 cm deep in seed furrows.
- **Pest management:**
 - Pod borers cause maximum damage. For controlling pod borer spray of 250 ml Dimecron or 1.5 ltr of Thiodin in 1000 ltr of water/ha at the time of flowering and at pod formation is recommended.

Lalitpur

- **Varieties:** Radhey and Avrodhi, KWR 108, DCP 92-3,
- **Seed rate:** 80 kg/ha
- **Nutrient management:** 15 kg N + 40 kg P₂O₅ + 14 kg K₂O + 20 kg S/ha
- **Pest management**
 - Pod borers cause maximum damage. IPM package should be followed, Monitor moth population through sex pheromones trap. Spray 5 % NSKE at flowering / pod formation followed by NPV 250 LE and endosulfan (0.07%) if vrequired.
- **Some other important practices**
 - Seed inoculation with Rhizobium

Suitable cropping systems

Etawah

- Sunflower + chickpea
- Sorghum (Fodder) + chickpea
- Barley + chickpea (2:1)
- Sesamum + chickpea
- Wheat + chickpea
- Chickpea + safflower
- Alternate crops: Greengram, blackgram, soybean, sunflower in place of Kakun, Kodan and Filkar (small millet)

Fatehpur

- Sunflower + chickpea
- Sorghum (fodder) + chickpea
- Barley + chickpea (2:1)
- Wheat + chickpea
- Chickpea + linseed
- Chickpea + safflower

Kanpur (Rural), Kanpur (Urban)

- Rice - chickpea
- Chickpea + Linseed (2:1)
- Sesamum - chickpea
- Wheat + chickpea(4:2)
- Chickpea + safflower (4:1)
- Alternate crops: Greengram, blackgram, soybean, sunflower in place of Kakun, Kodan, Filkar (small millet)

Lalitpur

- Sorghum (fodder) - chickpea
- Barley + chickpea (2:1)
- Sesamum - chickpea
- Wheat + chickpea
- Chickpea + safflower
- Chickpea + linseed
- Alternate crops: Greengram, blackgram, soybean, sunflower in place of Kakun, Kodan, Filkar (small millet)

Farm implements/ tools

Etawah

- Shivaji seed cum ferti drill

Fatehpur, Lalitpur

- Seed cum ferti drill

Kanpur (Rural), Kanpur (Urban)

- Star Weeder

Alternate farming systems

Etawah

- **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*
- **Fruits:** Mango, guava, amla, phalsa, jamun, karonda, *Papaver somniferum*, *Palmarosa*, *Cymbopogon flexuosus*, *Vetiveria zizanioides*
- **Vegetables:** Tomato, chillies, brinjal, okra, bottle gourd, cowpea
- **Animal component:** Female buffalo/ sheep, goat

Fatehpur, Kanpur (Rural), Kanpur (Urban)

- Ley farming- Four year continuum raising of *Stylosanthes hamata* - sorghum
- **Fodder/ green biomass:** *Leucaena leucocephala*, *Azadirachta indica*, *Albizia lebbbeck*, *Bauhinia purpurea*, *A. procera*, *B.monosperma*, *A.amara*, *D.sissoo*
- **Fruits:** Guava, Amla, Ber, Mango Bael, Jamun
- **Medicinal/ Aromatic Plants:** *Papaver somniferum*, *Cymbopogan flexuosus*, *Psoralea*, *Palmarosa*, *Vetiveria zizanoides*,
- **Vegetables:** Bottle gourd, Brinjal, Chillies, Cluster bean, Cowpea, Round melon
- **Animal Component:** Female Cattle, Male Cattle, Female Buffaloes, Sheep, Goats, Poultry

Lalitpur

- **Ley farming** - Four year continuum raising of *Stylosanthes hamata* - sorghum
- **Fodder/ green biomass:** *Leucaena*, *Melia azadirach*, *Dichro stachys cineraria*, *Albizia amara*, *A.lebbbeck*, *Hardwickia binata*, *A.nilotica*
- **Fruits:** *Emblica officinalis* (amla), guava, ber, mango
- **Medicinal and aromatic plants:** *Rauvolfia serpentina*, *Vetivera zizanoides*, *Palmarosa*, *Safed musli*, *Aswagandha*.
- **Vegetables:** Bottle gourd, brinjal, tomato, chillies, brinjal, cowpea, okra
- **Animal component:** Female cattle, male cattle, female buffaloes, goats, poultry.

Contingent planning

Etawah

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.

Fatehpur, Kanpur (Rural), Kanpur (Rural)

• Normal Season

Kharif

- Rice (N-967, N-118, Baranideep, Pant Dhan 12, NDR 359)
- Maize (Jaunpuri, Tipakhiya, other hybrids)
- Sorghum (PKV-400, Varsha, other hybrids)
- Pearl millet (Manupur, WCC-75)
- Pigeonpea (UPAS-120, Bahar, NA 1, Malviya Arhar 13)
- Blackgram (T-9, Narendra Blackgram-1, Uttara, Pant U 35)
- Greengram (Pant Moong-54, Narendra Moong-1)

Rabi

- Chickpea (Avrodhi, DCP 92-3, BG 256, Karnal chana 1)
- Lentil (NDL-2, DPL-15, sheri)
- Rapeseed mustard (Vibhav, Varuna)
- Linseed (Garima, Sweta)
- Wheat (Atal, C-306, K-8027)
- Barley (Lakhan, Narendra Jau-4)
- Compatible genotypes for cropping system:
 - Sequence (Rice (NDR 359) - Lentil (sheri))
 - Intercropping (Linseed (Avrodhi) + Chickpea (Sweta))

Aberrant weather

• Normal onset of monsoon followed by long gaps in rainfall

- In case of very early break in monsoon i.e. 7-10 days after seeding and if seedlings withered resow with the same variety.
- Gap filling/ transplanting in case of cereals like uplands rice and pearl millet may be done if drought occurs about a month after seeding and is followed by showers. Follow this by light top-dressing i.e. 10-15 kg N/ha. For this purpose community nurseries of emergency nurseries should be kept ready.

• Delayed onset of monsoon

- If monsoon sets in as late as the last week of July, short duration uplands rice such as Narendra-118 and Baranideep are recommended if the rains are delayed beyond the period but start somewhere in the first week of second week of August and growing season is reduced to 60-70 days, then the cultivation of pearl millet (WCC-75, Mannpur), blackgram (Narendra Blackgram-1) and greengram (Pant Moong-1) should be taken up. Yet another alternative could be to harvest a fodder of either sorghum, pearl millet, maize or a mixture of either of cowpea, blackgram, greengram one of the above fodder crops. These crops will be followed by *rabi* crops like chickpea, rapeseed mustard and barley.

- **Early stoppage of rains towards the end of season**
 - Normal sowing of short duration *kharif* crops such as upland rice (N-97, Pant Dhan 2, Mutmuri), blackgram (uttara), sesamum (T-13) may be done. Sorghum, maize, pearl millet and cowpea for fodder could be harvested. If the rain stops very early, i.e. by the end of August or first week of September, only fodder crops and grain legumes could be harvested. Later on as a mid-season correction sunflower could be planted as it could be planted as it could be sown any time in the year.
 - Depending on the soil moisture condition, relay sowing of *rabi* crops such as chickpea, lentil, linseed and barley could be done in the *rabi* season.
- **In extreme drought conditions**
 - Only short duration crops like grain legumes (black and greengram) should be grown.
 - Among cereals, maize (Tipekhiya) gave a fair performance
 - Intercropping maize in interrows of pigeonpea was found successful
 - Rice crop, if already sown is not likely to succeed, may be ploughed under to conserve the moisture in the soil. This may permit growing of chickpea, rapeseed mustard or barley during *rabi*.

District	Region
Mirzapur	Low runoff and medium yield gap

Agro-geographic Setting

- **Climate:** Hot moist/ Dry sub humid
- **Physiography:** Bundelkhand Uplands
- **Soils:** Inceptisols - 60%; Udupts/ Udalfs - 40%
- **Annual rainfall:** 1112 mm
- **Potential evapotranspiration:** 1527 mm
- **Moisture availability period:** 150-180 days

Soil and water conservation

- Inter-plot water harvesting
- Raised bed and sunken system

Crop management

- **Varieties:** KWR 108, BG 256, JG 315, Radhey, K 850
- **Seed rate:** 80 kg/ha
- **Planting pattern:** 30 cm
- **Nutrient management:** 20 kg N + 40 kg P₂O₅ + 20 kg K₂O/ ha. Place fertilizer 10 - 15 cm deep in the seed furrows.
- **Pest management**
 - Pod borers cause maximum damage. For controlling pod borer spray of 50 ml Dimecron or 1.5 l. Thiodon in 1000 l of water/ha at the time of flowering and at pod formation is recommended

Suitable cropping systems

- Rice - chickpea
- Pearl millet - chickpea
- Chickpea + rapeseed mustard (4:1)
- Chickpea + barley (3:1)
- Chickpea + linseed (3:1)
- Sesamum - chickpea
- Blackgram - chickpea

Farm Implements

- Bullock drawn Malviya multi-farming machine: For field preparation; for seeding dryland crops and fertilizing through mechanical metering device; for intercultivation between two plant rows (particularly *Kharif* season crop); Rs.2350/-
- Dryland weeder (modified form of weeder supplied by T.A.U): For weed control between plant rows of rainfed crops; Rs.70/-

Alternate farming systems

- Ley farming - Four year continuum raising of *stylosanthes hamata* - sorghum
- Forage sorghum - safflower
- Forage sorghum - chickpea/ lentil/ mustard/ black soils
- Fodder cowpea/ sesbania + grain sorghum
- Pigeonpea + forage sorghum/ teosinte/ maize/ pearl millet/ sudan grass/ cowpea/ clusterbean/ sun hemp
- **Fodder/ green biomass:** *Leucaena leucocephala*, *Azadirachta indica*, *Albizia lebbbeck*, *Bauhinia purpurea*, *A. procera*, *B.monosperma*, *A.amara*, *D.sissoo*
- **Fruits:** Guava, amla, ber, mango, bael, jamun
- **Medicinal and aromatic plants:** *Pepaver somniferum*, *Cymbopogon flexuosus*, *Psoralea*, *Palmarosa*, *Vetiveria zizanooides*
- **Vegetables:** Bottle gourd, brinjal, chillies, cluster bean, cowpea, round melon
- **Animal component:** Female and male cattle, female buffaloes, sheep, goat, poultry

Contingent planning

- **Normal season**

Kharif

- Rice (NDR-97, NDR-118, Govind, Vandana)
- Maize (Ganga safed 2, Knachan, Jaunpuri, other hybrids)
- Pearl millet (BJ 104, Pusa 23, Pusa 322)
- Blackgram (T.9, Pant U-19, Pant U -35)
- Greengram (Jagriti, Janpriya, Pant moong-12, Narendra moong-1, Samrat)

- Sesame (T4, T12, Gujrat sesame-1)
- Pigeonpea (Bahar, NA-1, T21, Malviya arhar 13)

Rabi

- Lentil (Pant L-406, Pant L-639, L 4076, K 75, sheri)
- Wheat (HUW-533, K-8027, C-306)
- Barley (DL3, Jyoti, K125)
- Rapeseed mustard (Varuna, Vardhan, Sanjukta, Kranthi)
- Linseed (Garima, Neelam)
- Chickpea (Pusa 256, Awarodhi, JG 375, JG 74)

Contingent planning

- **Normal onset of monsoon followed by long gaps in rainfall**
 - In the case of very early break in monsoon i.e. 7-10 days after seeding and if seedlings are killed resow with the same variety.
 - Gap filling/ transplanting in case of cereals like upland rice and pearl millet may be done if drought occurs about a month after seeding and is followed by showers. Follow this by light top dressing i.e. 10-15 kg/ha. For this purpose community nurseries or emergency nurseries should be kept ready.
- **Delayed onset of monsoon**
 - If monsoon sets in as late as the last week of July, short duration upland rice such as NDR-97 and Vandana are recommended on medium and low lands. Uplands should be considered for pigeonpea base intercrop. If rains are delayed beyond the period but start somewhere in the first to second week of August and growing season is reduced to 60-70 days, then the cultivation of hybrid pearl millet (BJ560, BJ.104), blackgram (T9, Uttara), greengram (Jagriti, Jyoti, Samrat) should be taken up. Pulse base intercropping is also recommended. Yet another alternative could be to harvest a fodder of sorghum, pearl millet, maize or mixture of either of cowpea, blackgram, greengram and one of the above fodder crops. Winter crops like rapeseed mustard, barley, lentil, linseed and chickpea will follow these crops.
- **Early stoppage of rains towards the end of season**
 - Normal growing of short duration *khariif* crops such as upland rice (NDR-97 or Vandana), blackgram (T.9), sesame (T.13) may be done. Sorghum, maize, pearl millet and cowpea for fodder could be harvested. If the rain stops very early, i.e. by the end of August or first week of September, only fodder crops and grain legumes could be harvested. Later on as a mid-season correction sunflower could be planted as it could be sown any time in the year.
- **In extreme drought conditions**
 - Only short duration crops like grain legumes (black and greengram) should be grown
 - Among cereals, pearl millet (BJ.104) gave a fair performance
 - Intercropping blackgram in interrows of pigeonpea was found successful
 - Rice crop, if already sown is not likely to succeed, may be ploughed under to conserve the moisture in the soil. This may permit growing of lentil, chickpea, rapeseed mustard or barley during *rabi*
 - Late season drought coinciding with reproductive phase of upland rice is frequently experienced (3/7years). If period of drought approaches 8-10 days, 25% yield could be compensated by one life saving irrigation (5 cm depth)

CHICKPEA CULTIVATION

More than three-fourths of chickpea crop is rainfed. In the recent past, chickpea made way into the States of AP, Karnataka and Maharashtra due to the impact of technology especially variety and the economics. The range of productivity varies from 0.09 to 1.7 t/ha. Most of the area is in the medium productivity range of 0.56 to 1.1 t/ha covering an area of 3.8 m.ha. Significant area is under low productivity of 1.19 m.ha. As expected the low annual rainfall coincides with low productivity and vice-versa. The time of occurrence of peak of monthly rainfall towards *rabi* season coincided more with productivity than amount. Being a *rabi* crop, chickpea fits very well in the sequence cropping systems in north and central India. The major pulse based cropping systems in the relevant agro ecoregions (AERs). Agro-ecoregions are that listed by National Bureau of Soil Survey and Land Use Planning, Nagpur.

Major Chickpea based production systems

States	Cropping system
Andhra Pradesh, Karnataka (<i>Agroecoregion-3</i>)	Fingermillet/ groundnut/ pearl millet- chickpea/ safflower/ <i>rabi</i> sorghum + chickpea
Punjab, Haryana, Gujarat, Rajasthan, Madhya Pradesh, Uttar Pradesh (<i>Agro ecoregion-4</i>)	Pearlmillet/ maize/ groundnut/ fallow - chickpea
Madhya Pradesh, Gujrat (<i>Agroecoregion-5</i>)	Wheat + chickpea/maize/ sorghum - chickpea
Maharashtra, Karanataka (<i>Agroecoregion-6</i>)	Pearlmillet/ sunflower- chickpea
Andhra Pradesh (<i>Agroecoregion-7</i>)	Fallow- chickpea, sorghum - chickpea
Karnataka, Tamil Nadu (<i>Agroecoregion-8</i>)	Fingermillet/ groundnut/ pearl millet - chickpea
Punjab, Bihar, Uttar Pradesh (<i>Agroecoregion-9</i>)	Maize/ rice - chickpea
Madhya Pradesh, Maharashtra (<i>Agroecoregion-10</i>)	Rice/ sorghum/ blackgram - chickpea/ wheat + chickpea
Chhattisgarh, Jarkhand (<i>Agroecoregion-11</i>)	Fallow/ rice/ sesame - chickpea
West Bengal, Jharkhand, Orissa (<i>Agroecoregion-12</i>)	Rice - chickpea
Uttar Pradesh, Bihar (<i>Agroecoregion-13</i>)	Rice - chickpea

Land preparation

Chickpea needs clodded and rough seedbed for good aeration in root zone; thus a suitable seedbed may be obtained by one deep ploughing followed by two harrowings. In diara lands one ploughing by desi plough brings about cloddy condition and the crop can be sown. Disc harrowing was beneficial to chickpea in aridsols of Hisar over six years over country plough. The post monsoon crops like chickpea suffer from the continuous increasing stress due to recession in the soil moisture. These crops suffer initially for want of germination due to seeding in dry zone. These crops need initial soil moisture build up by increasing infiltration through deep tillage and other practice and holding from soil moisture. Implements should be developed to place the seed in optimum moist zone. However, increasing depth of placement of seed would adversely affect the germinated seed in case of long dry path before the priming emerges out of soil. Thus, the practice aims at early planting before the topsoil dries up. Most of the chickpea and lentil are grown in high severity from water-eroded region. It is important to reduce evaporation from the soil surface covering with the mulches. Providing supplemental irrigation from time to time based upon ET or critical period from sealed ponds for a post rainy season crop assures more income.

Seed Priming

Soaking the seeds and then drying to its original moisture content. It advances germination and emergence; rapid development of root system; improves growth and development and enhances yield.

For 1 kg of seed mix 0.5 g sodium molybdate, 4 g rhizobium culture in one litre of water, make it slurry, soak the seeds (4 hrs for kabuli and 8 hrs for non-kabuli) and shade dry it one hour before sowing.

On- farm trials during 1998-99 and 1999-00 revealed that the priming increased the average yield by almost 50 % in first year and by 20 % in second year (DFID). Generally a seed rate of 75 to 100 kg/ha based on seed weight and planting time. A row spacing of 30 to 45 cm should be used.

Germination and seed rates

Number of seeds germinated (out of 50)	Extra seed required (as % of the normal)
50	Normal
48	5
46	10
44	15
42	20
40	25

Seeds should be treated with carbendazim or Thiram or Captan @ 2 g / kg seed atleast 3 days before sowing. Seed inoculation with rhizobium culture enhanced productivity by 10-12 % inoculates seed with appropriate rhizobium culture (250 g culture / 10 kg seed) 10-12 hours before sowing.

Sowing

Second fortnight of October in north India and first fortnight in central and south india is found to be the best sowing time but it may be delayed by first week of November if supplemental irrigation facility exists for higher yields. The seed rate is decided by seed weight and planting time. In Northwest Plain Zone (Punjab, Haryana, Western U.P. and Rajasthan) Popularize summer greengram and spring blackgram as catch crops. Timely sowing, preferably by mid June of early pigeonpea, first week of July for late pigeonpea, mid July for blackgram and greengram and first fortnight of November of chickpea, pea and lentil. Use recommended seed rate to maintain optimum plant population of 1.5-2.0 lakhs for early pigeonpea, 3.33 lakhs for *kharif* blackgram/ greengram, 7-8 lakhs for summer greengram, 2.5-3.6 lakhs for chickpea and pea. Plant the crop at proper spacing; greengram, blackgram, chickpea at 30-35 cm, and pigeonpea at 45 cm in case of early duration varieties and 60 cm in case of late duration varieties. Use short duration (140-150 days) genotypes of pigeonpea for double cropping with wheat. Grow greengram as catch crop after the harvesting of wheat crop in the first week of April. Grow blackgram in the first fortnight of March after the harvesting of potato and sugarcane ratoons. Intercrop short duration legumes with sorghum, pearl millet and sugarcane. Adopt pair row planting in case of pigeonpea + sorghum and pearl millet + blackgram/ greengram intercropping.

In North East Plain Zone (Eastern U.P., Bihar, West Bengal, Orissa and Assam), Use short duration chickpea genotype like KPG 59 and BG 256 for sequential cropping with rice. Ensure timely sowing, preferably 2nd fortnight of June for early pigeonpea, 1st fortnight of July for late pigeonpea, blackgram/ greengram, 4th week of October for chickpea and *rajmash*, 1st fortnight of November of pea and 3rd week or October to 1st week of December for lentil. Sow pigeonpea on ridges wherever water stagnation is a problem. Popularize *rabi* pigeonpea and plant the crop during the 1st fortnight of September. Popularize summer planting of pigeonpea in the irrigation areas and plant the crop in the first fortnight of April after the harvesting of wheat crop. Adopt companion cropping of pulses with sugarcane such as blackgram/ greengram with spring sugarcane and lentil with autumn planted sugarcane. Plant 1-2 lines of pulses within two lines of sugarcane spaced at 90 cm. Adopt paired row planting wherever intercropping of pigeonpea + sorghum, pearl millet + blackgram/ greengram is feasible.

In Central Zone (Madhya Pradesh, Gujarat, Maharashtra), Adopt moisture conservation techniques. Sow timely, preferably in the first week of July with the onset of monsoon for pigeonpea, blackgram and greengram and 2nd fortnight of October for chickpea, pea and lentil. Use recommended seed rate in order to maintain plant population of 80,000-90,000 plants/ha for pigeonpea, 7-8 lakhs for spring-summer blackgram/ greengram and 3.33 lakhs per hectare for chickpea *kharif* blackgram. Plant pulses in rows. Adopt spacing of 60-75 x 20 cm for late pigeonpea and 30 x 10 cm for blackgram, greengram and chickpea. Intercrop short duration legumes with cotton, sorghum, pigeonpea and pearl millet. Soybean intercropped with

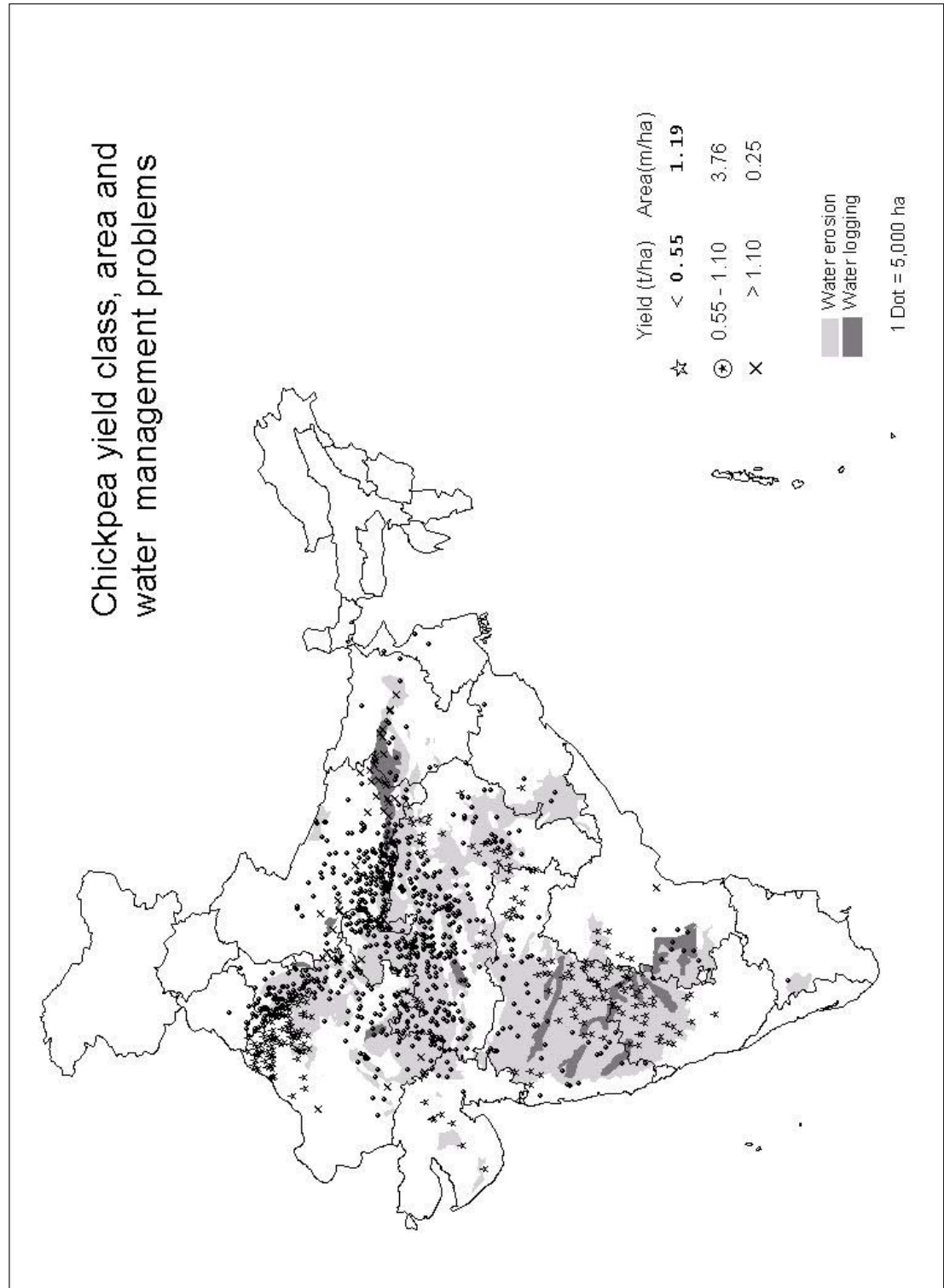
pigeonpea (4:2 row ratio) in Madhya Pradesh is a better intercropping system. Popularize spring/ summer greengram in irrigated areas of Madhya Pradesh and Gujarat.

In Peninsular Zone (Karnataka, Tamil Nadu, Andhra Pradesh and Kerala), Sow timely preferably in the first fortnight of July in case of *kharif* blackgram, greengram and medium - late pigeonpea, and 2nd fortnight of October is the best time for *rabi* pulses. Use recommended seed rate for maintain plant population of 1.5 lakhs/ha for pigeonpea and 3.33 lakhs for blackgram and greengram. Intercrop short duration legumes with cotton and sorghum, and pigeonpea with groundnut.

Promising varieties for different States

States	Varieties
Andhra Pradesh	Bharati, Sweta, JG 11, ICCC 4, Annegeri , Kranti
Assam	Radhey, JG 74, KPG 59
Bihar	Pusa 372, Pusa 256, Pusa 1003, C 235, L 550, Udai, KWR 108, Gujarat Gram 4, RAU 52
Gujarat	Dahod yellow, Chaffa, Pus a 212, Pus a 417, Pusa 372, Pusa 391, Vishwas, Vikas, Vijay, Vishal, Dharwad Pragati, Gujarat Gram 1, ICCC 4, Gujarat Gram 2, KAK 2
Haryana	Gaurav, L 550, Pusa 261, Pusa 329, Pusa 372, Pusa 362, Pusa 267, ICCC 32, Gaurav, PBG 1, Haryana Chana 1, Udai, Kamal Chana 1, DCP 92-3, Samrat, Vardan, GPF 2, Alok, Chamatkar, Gora Hisari
Himachal Pradesh	C 235, ICCC 32
Jammu & Kashmir	C 235, DCP 92-3, Kamal Chana 1, GNG 469, PBG 1
Karnataka	Annegeri 1, Chaffa, Bharati, JG 11
Madhya Pradesh	JG 74, JG 315, JG 322, JG 281, Pus a 417, Pusa 212, Pusa 391, Vishwas, Ujjain 21, Radhey, Vikas, Vijay, Vishal, Dharwad Pragati, Gujarat Gram 1, JGG 1, KAK 2
Maharashtra	Chaffa, Pus a 372, Pusa 391, Phule G 5, JG 315, Dharwad Pragati, Gujarat Gram 1, Sweta, KAK 2, Annegeri 1, Vishal, Vijay, Vikas, Phule G 12
Manipur	Radhey, JG 74
Meghalaya	Radhey, J G 74
Orissa	Radhey, Pusa 391
Punjab	C 235, GNG 146, Pusa 261, Pusa 256, PBG 1, Haryana Chana 1, Udai, Pus a 329, Pusa 372, DCP 92-3, Vardan, Samrat, GPF 2, Pusa 362, Alok, PBG 3, L 550, ICCC 32, Pus a 267, Kamal Chana 1, L 551, Chamatkar, GL 769, Hare Chhole 1
Rajasthan	C 235, Dahod yellow, Pusa 261, Pusa 256, Pus a 267, ICCC 32, Pus a 212, RSG 44, Gaurav, GNG 146, PBG 1, Haryana Chana 1, Udai, Pus a 329, Pus a 372, DCP 92-3, GNG 663, GPF 2, Samrat, Pusa 362, Alok, Kamal Chana 1, L 550, Chamatkar
Tamil Nadu	Bharati, JG 11, CO 3, CO 4
Tripura	Radhey, JG 74
Uttar Pradesh	K 850, Pant G 186, KWR 108, Pusa 256, Pusa 372, GNG 146, Vardan, JG 315, Udai, Alok, Vishwas, PBG 1, Haryana Chana 1, DCP 92-3, Samrat, GPF 2, Gaurav, Kamal Chana 1, Pus a 1003, Gujarat Gram 4, Radhey, Avrodhi, Sadhbahar, Sadbhawana, Pragati, Surya
West Bengal	JG 74, Pusa 256, KWR 108, Mahamaya 1, Mahamaya 2
Delhi	KPG 59, DCP 92-3, Alok, Kamal Chana 1
Dadra & Nagar Haveli	Dahod yellow, ICCC 4

Bold types are state releases



Fertilizer Management

Adequate and balanced supply of plant nutrients is a prerequisite for achieving and sustaining higher productivity. Pulse crops are energy rich crops and remove sizable quantity of nutrients from the soil. While chickpea producing 1.5 tonnes seed ha⁻¹ removes 91, 6, 49 and 13 kg N, P, K and S ha⁻¹ respectively. Nutrient uptake by pulse crops (Table 9) indicate 1.2 t h⁻¹ of economic yield of pigeonpea removes 85 kg N, 8 kg P and 16 kg K and 9 kg S ha⁻¹. Because of low soil fertility and continuous nutrient depletion in soils, pulses now respond to external supply of nutrients. In northern region, pulses respond up to 40 kg P₂O₅ ha⁻¹ significantly, but in some cases the response had been up to 75 kg P₂O₅ ha⁻¹. N, P₂O₅, K₂O, and S uptake by chickpea were 91, 6, 49, and 13 kg/ha with a yield of 1.5 t/ha. Some fertilizer recommendations (Table 2) follow: Being a leguminous crop chickpea does not respond to higher dose of nitrogen for a starter dose 10-12 kg N/ha is recommended. Phosphorus and sulphur are deficient in most of the chickpea growing regions. Therefore, band application of 40-50 kg P₂O₅ and 20 kg S/ha is recommended. Response to potassium is inconsistent. the areas having low to moderate status application of 20 kg K₂O/ha is beneficial.

Optimum fertilizer dose

State	Nutrient doses (kg/ha)	
	N	P ₂ O ₅
Bihar (Plateau)	20	40
Haryana	20	40
J & K	15	45
Madhya Pradesh	20	40
Malwa	40	60
Rewa	20	50
Uttar Pradesh	20	40
Bundelkhand	10	40
Semi arid, South-West	10	40
Submontane	0	60-75

Next to N, phosphorus is another nutrient element, which is critical for achieving good yields in dryland. There are numerous reports which have described the responses of P in dryland crops (Tandon, 1986; Sharma and Das, 1992; Singh and Das (1995). Retrieval of P recommendation data generated by various centers of All India Coordinated Research Project for Dryland Agriculture (AICRPDA) show that out of 113 situations (28 x locations), the quantities recommended (kg P₂O₅) were 15 - 30 kg in 35% cases, 30-45 kg in 56% cases and 45-60 kg P₂O/ha in 9% situations (AICRPDA, 1983).

Some recommendations on micronutrient application are CO chloride @ 1 kg ha⁻¹ or sodium molybdate @ 1 kg ha⁻¹ or Zinc sulphate @ 25 kg ha⁻¹ (Namdeo and Gupta 1992), 25 kg Zn SO₄ per kg⁻¹ (Singh 1986), and 5-10 kg borax/ha in calcareous soils (Ali 1995)

Significant increases in yield of legumes to basal application of 20-30 kg N ha⁻¹ have been reported for several legumes (Tandon 1992). These experiments have been conducted mostly on low N soils. In general, N levels reduce nodulation and nitrogen fixation. Under such circumstances, BNF contribution from legumes can be improved by managing soil N either through inclusion of appropriate nitrogen tolerant high N₂ fixing legume crops or by appropriate management practices. However, there could be many overriding factors like profitability, suitability and preference for home consumption. A high level of soil mineral N (31.2 ppm) at sowing reduced nodulation of chickpea on a vertisol by 14% and proportion of fixed N by 63% compared to control plot (7.3 ppm).

High levels of mineral nitrogen in the soil suppress biological N fixation (BNF) by 50% (Rupela and Johanson 1995). In a sorghum-chickpea, increasing N fertilizer levels to the preceding sorghum on a Vertisol-increased soil N level at sowing of chickpea. The increased soil N levels suppressed BNF by chickpea. Thus, high use of N annually seems to be making soils unfit for harnessing BNF. Alternatively, it may need

legume varieties whose BNF system can tolerate high concentration of soil N. The organic N in legume residues, especially roots, can act as slow release N fertilizer to increase N use efficiency. Some N and P fertilizer schedules are given.

Total nitrogen (N) and mineral-N in top 15 cm of a vertisol at the time of sowing chickpea, 1990-95, ICRISAT, Patancheru

N-application to preceding sorghum	Total N ¹ (mg kg ⁻¹ soil)		Mineral N (mg kg ⁻¹ soil)	
	Nodulated chickpea	Non-nodulated chickpea	Nodulated chickpea	Non-nodulated chickpea
0	561	517	16	14
50	549	527	18	15
100	636	544	22	23
150	617	583	26	27
SE	±12.8 (17.2) ³		±2.5 (1.4) ³	

¹ The data for total N are based on four years

Despite the negative N balances for the legume crops in rotation or as intercrops reported benefits of legumes to succeeding non-legume crops have been also observed consistently. The residual effect of chickpea on maize and pearl millet were 60-70 and 40 kg/ha fertilizer N equivalent (Wani *et al.*, 1994). Growing legumes in rotation does improve mineral N content in soil as compared with the cultivation of non-legume crops (Rao and Singh 1991; Wani *et al.* 1995; Ladha *et al.* 1996). Herridge *et al.* (1995) reported that 3-141 kg/ha N fixed, 14 kg/ha N additional soil nitrate (Calculated as the difference between levels of soil nitrate after a legume and after a cereal crop or a period of fallow) with 0.80 N harvest index. However, it does not fully explain the beneficial effects of legumes on the succeeding crop.

Symbiotic partnership between pulse crops and *Rhizobium* under best compatibility and crop management supplies approximately 80-90 per cent of total N required by the crop. However, the N contribution depends on the effectiveness of *Rhizobium* strains, its compatibility with the host, biomass accumulation of host, soil and environmental factors. Recent estimates indicated fixation of 3-330 kg N ha⁻¹ under different agro-climatic conditions. The pulses utilize majority of the fixed N for their growth, and also leave some residual amount of N in soil for the succeeding crops. The net nitrogen balances calculated for several cultivars chickpea grown at Gwalior, Madhya Pradesh, India, indicated that all the varieties depleted soil nitrogen. These results show that legumes also mine soil N as do cereals. In chickpea-based cropping systems, sorghum yields were 18-24% more than the Sorghum + Safflower plot yields. Total soil N in soil samples were 567 (in 1983) and 507 (in 1993) ppm in 0-15 cm and 399 (in 1983) and 446 (in 1993) ppm in fallow chickpea followed by fallow-sorghum plots (Wani *et al.* (1994).

The other likely benefits include increased availability of nutrients other than N (through increased total soil microbial activity and/or increased activity of such specific groups of micro-organisms as vesicular Arbuscular mycorrhizae or plant growth promoting rhizobacteria), improved soil structure, enhanced level of growth-promoting substances, and reduced pest and disease incidence. The extent of these benefits is dictated by site, season, and crop sequence. A dependable methodology to quantify the benefits derived from these different factors may be difficult to evolve, and will require long-term studies. However, a legume-based rotation is generally more sustainable than a rotation without a legume. Extra yield from a rotation can result from:

- Increased availability of nutrients other than N such as K, Ca, magnesium, Zn, S, and Fe through increased soil microbial activity, deep rooting, and root exudates (Ladha *et al.* 1989b; Wani *et al.* 1991).
- Improvements in soil structure, mainly soil aggregate formation following legumes (Latif *et al.* 1992);
- Improvements in soil water-holding and buffering capacity with incorporation of legume residues (Buresh and De Datta 1991).

- Growth promoting substances in legume residues (Ries *et al.* 1977).

Information on the effect of salinity and alkalinity on rhizobia is scanty, and it is particularly lacking for chickpea and pigeonpea. The pH of sodic soils is usually above 8.5% and can result in reduced availability of phosphorus P, Fe, Zn, and Mn for plant growth. There is a considerable variation in the decrease of resistance to salinity across legume species. Chickpea is prone to salinity damage. It was suggested that salts affect the host rather than *Rhizobium*. However, the processes involving an interaction between the two are likely to be more sensitive to salinity and alkalinity (Lakshmi Kumari *et al.* 1974). Plants depending on symbiotic nitrogen were more affected by salts than those depending on mineral nitrogen. *Rhizobium* strains obtained from salt-affected soils may be more tolerant to salinity and better able to establish a symbiosis with the host. Chickpea strain IC-53 (ex 161a), isolated from a saline field at ICRISAT Center, produced greater shoot weight than *Rhizobium* strains from normal fields, when compared in pots containing saline soil. This strain produced 63% more grain yield than the control in field trials in a saline soil in Sudan (Ibrahim and Salih 1980).

Experiments on farmers' fields were conducted under AICPIP have determined the response of pulse crops to applied P. Based upon the results of 709 trials on chickpea, 583 on Pea, 173 on greengram and 177 on blackgram, it was found that the mean response to each kg of P applied at 29.4 kg P ha⁻¹ was 3.1, 6.0, 1.6, and 3.0 kg grain respectively (Prasad 1979). Since most of the soils are rich in K, response to applied K is either low or absent. The sulphur deficiency is more pronounced with the use of sulphur through fertilizer. Ali and Singh 1995 reviewed results of coordinated trials of AICPIP and concluded that gypsum, pirate and single super phosphate are almost identical as source of sulphur. Genotype variation to susceptibility to deficiency of micronutrients has been observed in cowpea, lentil, and pigeonpea (Ahlawat and Ali 1993).

The cost of production can be reduced by incorporating organic residues and still produce more or equivalent yield to that of inorganic fertilizer application apart from benefiting from other reasons.

Integrated nutrient management in pulses

Location (No. of years)	Treatment	Yield(Kg/ha ⁻¹)	Sustainability index
Bijapur (3)	15 N compost + 20 N urea	958	0.61
	100% recommended dose of N	927	0.59
	Farmers' practice (control)	474	0.27
Bijapur (3)	15 N compost + 10 N/ha (cereal + legume)	799	0.67
	15 N compost + 20 N urea	717	0.60
	Farmers' practice (control)	358	0.29
Indore (4)	100% recommended dose of fertilizer	1227	0.24
	50% recommended dose of fertilizer	849	0.03
	Farmers' practice (control)	849	0.03

I and II are the top first and second rated treatments: P and K refer to phosphate and potash

Some benefit /cost ratios for chickpea and pigeonpea in various states are given (Wani *et al.* 1994).

Economics of fertilizer use in chickpea

State	Benefit-cost ratio		
	N	P ₂ O ₅	K ₂ O
Andhra Pradesh	13.6	2.8	3.8
Bihar	14.0	3.3	6.7
Himachal Pradesh	9.0	5.2	8.6
Haryana	10.0	7.4	8.6

Karnataka	9.0	3.0	19.0
Madhya Pradesh	15.6	5.8	11.4
Maharashtra	7.0	2.9	4.8
Orissa	7.0	2.2	7.6
Punjab	8.6	3.3	1.0
Rajasthan	14.8	6.9	4.8
Uttar Pradesh	17.7	7.1	9.5

The benefit cost ratios for few pulses in various agro-climatic conditions to P application follows (Ganeshamurthy *et al* 2003).

Benefit-cost ratio of P application to pulse crops

Location		Response level of P (Kg P ₂ O ₅ ha ⁻¹)	Yield response Kg ha ⁻¹	Kg seed per kg P ₂ O ₅	Benefit: Cost ratio
North West Province Zone	Inceptisol	60	420	7.3	6.2
Central Zone	Vertisol (Medium deep)	60	200	3.3	2.8
Southern Zone	Vertisol (deep)	60	209	3.5	3.0

In North-West Plain Zone (Punjab, Haryana, Western U.P. and Rajasthan) Apply 25 kg zinc sulphate per hectare particularly in light soils in North-West Plain Zone (Punjab, Haryana, Western U.P. and Rajasthan)

In North East Plain Zone (Eastern U.P., Bihar, West Bengal, Orissa and Assam), In plateau region of Bihar, apply 2-4 t lime/ha to correct acidity

Nipping

It is a special practice of plucking top 2-3 leaves alongwith apical growing buds of the crop at about 30-40 days after sowing. Nipping promotes the lateral branching, thus the plants become more vigorous and produce more flowers and pods and yield per plant is increased.

Weed management

In early stages of crop growth, legumes are poor competitors to weeds and consequently suffer heavy yield losses. Studies under AICPIP during 1983-85 revealed high loss 0.78 t ha⁻¹ (42% in chickpea over weed free plots). Among various practices, pre-emergence application of pendimethalin at 1.0 - 1.5 kg ha⁻¹, metolachlor at 1.0 to 1.5 kg ha⁻¹ and pre-plant incorporation of 1.0 kg ha⁻¹ fluchloralin were effective in controlling seasonal weeds in chickpea, in northern India (Ali 1994b). High doses of herbicides adversely effects nodulation. Intercropping of short statured legumes such as blackgram, greengram, and cowpea helps in smothering weeds and enhancing crop productivity. Cowpea followed by greengram is efficient in smothering weeds. Therefore, it is imperative to grow dense canopy legumes both as a sole crop and intercrops to suppress weeds besides improving physical and biological conditions of soil and high economic returns. Chickpea responds well to hand weeding and hoeing as it improves aeration. The best time for weeding and hoeing is between 25-30 days after sowing and if the weeds are still present in the field, the second weeding should be done about 60 days after sowing. Weeds may be controlled by herbicides fluchloralin @1 kg a.i. per hectare should be used as preplant incorporation soil or pendimethalin @ 1.0-1.25 kg a.i./ha as pre emergence application.

In Northwest Plain Zone (Punjab, Haryana, Western U.P. and Rajasthan), Adhere to timely weed control. Keep the field weed free for the initial 6 weeks. Apply 1.0 kg pendimethalin or 1.0 kg Basalin/ ha (soil incorporation) before sowing. In North East Plain Zone (Eastern U.P., Bihar, West Bengal, Orissa and Assam), Ensure timely control of weeds. Apply pendimethalin 1.0 kg/ha or Basalin 1.0 kg a.i./ha (soil incorporation) before planting if feasible). In Central Zone (Madhya Pradesh, Gujarat, Maharashtra), Adhere to timely weed

control. Keep the fields free from weeds for initial 6-7 weeks. Apply pendimethalin 1.0 kg/ha or Basalin 1 kg a.i./ha (soil incorporation) or alachlor @ 2 kg/ha before planting. In Peninsular Zone (Karnataka, Tamil Nadu, Andhra Pradesh and Kerala), Adhere to timely weed control. Keep crop weed free during first 35-45 days growth.

Irrigation management

The crop is grown mostly under rainfed conditions where irrigations are not possible but researchers have found that in absence of winter rains, light irrigation improves productivity. There should be sufficient moisture in the soil while sowing the crop. A light irrigation at branching and a light irrigation at grain development stage are required for higher yield.

Plant protection measures

More than two dozen species of insects and other arthropod pests are known to attack chickpea crop in India. Amongst them, pod borer, cutworms, semiloopers, termite and aphids are of economic importance.

Damage to plants by pests have both above ground and underground have deleterious effects on plant growth. Major insect pests attacking pulses in different zones of the country are -

Zone	Pests
North East Plain	Cutworm, <i>Agrotis ipsilon</i> ; Gram pod borer, <i>Helicoverpa armigera</i> ; Semilooper, <i>Autographa nigrisigna</i>
North West Plain	Aphid, <i>Aphis craccivora</i> ; Gram pod borer, <i>Helicoverpa armigera</i> ; Termites, <i>Odontotermes</i> spp.
Central	Gram pod borer, <i>Helicoverpa armigera</i> ; Termite, <i>Odontotermes</i> spp
South	Gram pod borer, <i>Helicoverpa armigera</i>

Dipterans larva, (*Riverllia angulata*) and *Mytopina ciceri* in chickpea are causing higher damages in farmer fields (Sitanantham and Rupela 1986). Integration of insect repellent plant species as intercrop was helpful (Table 7).

Integrated pest management in chickpea at Varanasi

Treatments	Yield (kg/ha ⁻¹)
Chickpea	1759
Chickpea + garlic intercropping	2352

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Termite and cutworms: Soil or seed treatments should be practiced as a preventive measure against termites and cutworms in the fields having previous history of occurrence of these pests. These insect may be controlled by treating seeds with one litre aldrin 30 EC mixed in two litres of water and sprayed over one quintal seeds or soil application of 25 kg/ha Aldrin 5% or BHC 10% dust at field preparation. If attack appears after sowing, drench the soil through spraying with aldrin or lindane @ 0.03% E.C. in 1500 to 2000 litres of water.

Gram pod borer, semilooper and aphid: An integrated management system with more reliance on cultural practices and botanical pesticides has been developed. The cultural practices involve ploughing up the field after harvesting of the preceding crop to expose hibernating pupae of *Agrotis* and *Helicoverpa*, clean cultivation, removing plant debris, early planting, intercropping with mustard, linseed, coriander, etc. Care must be taken to conserve natural predators. Need based application of insecticides at appropriate time is necessary. Dusting the crop with BHC 10%, malathion 5%, carbaryl 5%, endosulfan 4% or phosalone 4% dust at the rate of 20 to 25 kg/ha in the early hours when the crop is wet with sufficient dew or spraying of the crop with insecticides such as endosulfan 0.07% or chlorpyrifos 0.07% or with botanical pesticides

like neem seed kernel extract 5%, Nimbecidin, Neemex, Achook or other neem based products or microbial products like NPV 250 LE, Delfin 1 litre per hectare provides effective control against gram pod borer. Synthetic and botanical/microbial insecticides should be sprayed alternatively to reduce the dose of chemical and to avoid development of insecticide resistance in the pests. Critical monitoring of moth population through pheromone trap is imperative to forewarn the epidemic of pest and decide the time of pesticide use.

Several microbial pathogens are known to infect the larvae of *Helicoverpa* sp. Infecting pulses. However, Nuclear Polyhedrosis Virus (NPV) has been the only pathogen extensively studied for its physico-chemical characteristics, pathogenicity, mass-production and persistence on foliage, soil and effect of host plants. Several adjuvants have been screened for increasing its effectiveness. The NPV has been found compatible with botanicals like neem seed extract, neem oil, and methanol extracts of *Ocimum sanctum*, *Acorous calamus*, *catharanthus rosues* and monocrotophos. Virus infection resulted in reduced parasitization by *Campoletis chloridae* under laboratory conditions however; under field conditions there was no adverse effect of virus application on percent parasitization by *C.chloridae* on chickpea. *Carcelia illota* a predominant parasite of *H.armigera* on pigeonpea was also not affected.

Extensive field trials and on-farm demonstrations have been conducted in several states on use of NPV for *Helicoverpa* control on pulses. Three sprays of NPV @ 250 LE/ha were found to give good control of *H.armigera* on pigeonpea while two sprays of NPV @ 500 LE/ha were equally effective as endosulfan 0.07% on chickpea. NPV along with adjuvant like egg albumen (0.06 per cent) and Tinopal (0.01 per cent) increases persistence and effectiveness of the virus. Spraying with knapsack sprayer or mist-blower was more effective than CDA. *Bacillus thuringensis* (Bt) when used alone was not effective in controlling the pest. However, a combination of Bt with NPV and endosulphan at reduced dosages was found promising in controlling the pest. The IPM module of sequential application of HaNPV 500 LE/ha endosulfan 0.075% and NSKE 5% with bird perches) and IPM module of sequential application of HaNPV 250 LE/ha + NSKE 2.5%, endosulphan 0.07% and HaNPV 250 le/HA + NSKE 2.5% with bird perches were effective against lepidopteren pod borer recorded highest % reduction of larval population.

About half a dozen insect species have been recorded to feed on chickpea. However, chickpea pod borer, (*H.armigera*) is the most important and is responsible for substantial losses in both the crops. Reed and Pawar (1982) reported that annual damage to pigeonpea and chickpea in India alone by *H.armigera* is to the tune of US\$200-300 million.

Several fungal, bacterial and viral diseases affect chickpea. Some of the important diseases causing substantial loss in chickpea production in different agro ecological zones of India are as follow:

Wilt: It is a soil borne fungal disease caused by *Fusarium oxysporum fsp. ciceri*. It is prevalent throughout the country but most serious in central zone. The disease generally appears after 3 weeks of sowing. Internal tissues from the collar region downwards become dark and discolored. The petioles and rachis along with leaflets droop down. Drooping starts from the upper part of the plant but soon the entire plant droops down. Sometimes only partial wilting of plants may occur. Several genotypes resistant to *Fusarium* wilt has been released for cultivation in wilt infested areas. Appropriate crop rotation, rouging out the infected plants from the field, and treating the seeds before sowing with 0.2% Thiram, Captan or bavistin (50%) @ 2.5 g/kg seed minimizes disease infestation.

Collar rot: It is a soil borne fungal disease caused by *Sclerotium rolfsii* Sacc. The disease mostly appears in the seedling stage under high soil moisture conditions. Young seedlings collapse, in older seedlings the leaves turn yellow and the plants dry up. Rotting of the stem can be seen at the collar region, the rotten portion of the stem is covered with whitish mycelial growth of the fungus and the disease may appear in patches in the field. Treating the seed before sowing with PCNB, Captan or Thiram fungicides @ 0.2% by weight, drenching the soil with PCNB (15-20 kg/ha) or demosan (15 kg/ha) and avoiding excessive soil moisture, control the disease infestation.

Black root rot: It is a soil borne fungal disease caused by *Rhizoctonia solani*. The disease generally occurs under high soil moisture at seedling stage. Affected seedlings gradually turn yellow and petioles and leaflets droop, generally the seedlings do not collapse. In the infected seedlings a distinct dark brown

lesion appears above the collar region on the main stem. Improved drainage, rouging the infected plants, growing resistant varieties, treating the seeds before sowing with PCNB, Captan or Thiram 0.2% by weight and soil application of PCNB or Thiram before sowing @ 25 kg/ha are recommended for management of black root rot.

Dry root rot: It is a soil borne fungal disease caused by *Rhizoctonia bataticola* (Taub But.). The disease generally appears around flowering and podding stages. The atmospheric temperature 30°C and above is favourable for the disease. The infected plants dry up, the petioles and leaflets of the infected plant droop only at the very top. Disease appears in scattered patches in the field. When the infected plants are pulled out, the taproot usually remains in soil, and turns dark showing signs of rotting. Growing resistant varieties, appropriate crop rotation, treating the seed with PCNB, Captan or Thiram 0.25 per cent and soil application of PCNB or Thiram before sowing @ 25 kg/ha minimizes disease infestation.

Stem rot: It is a soil borne fungal disease caused by *Sclerotinia sclerotiorum* (lib.) Mass. The disease appears on adult plants especially in the crop having thick canopy and excess soil moisture. The petioles and leaflets droop, the leaves dry up and turn straw coloured prematurely, a web of white mycelial strands appear on the infested parts of the stem and branches. Excessive moisture, which is conducive for stem rot should be avoided. Clean cultivation also helps in minimizing disease incidence.

Ascochyta blight: It is an air borne fungal disease caused by *Ascochyta rabiei* (Pases Labr.). It is most potential disease of North West Plains. Small circular brown spots appear on the leaves. These spots have discolored margin. Later black minute dots appear on necrotic lesions arranged in circles. High humidity favors this disease. Use of tolerant varieties like GNG 469, PBG 21, H 82-2, GNG 663, etc., rouging out the infected plants, seed treatment with arosen 75 @ 300g/100 kg of seed, spraying the crop with 0.2 per cent Captan or dithane Z 78 are the recommended control measures.

Botrytis grey mold: It is a fungal disease caused by *Botrytis cinerea* (Pers. Ex Fr). It is most common in *Tarai* region. Cool weather with high humidity favours disease occurrence. The disease appears on all parts of the plants except root system. Grey or dark brown lesions are seen on infected parts. Excessive vegetative growth is conducive for this disease. At present, genotypes resistant to BGM are not available, therefore, cultural practices such as wider spacing, intercropping, late planting, etc., should be followed.

Stunt: It is a viral disease mostly prevalent in Gujarat State. Plant is stunted with short internodes, leaflets are smaller and turn yellow, orange or brown, phloem tissues turn brown. Use of resistant varieties, control of leafhoppers and aphids and late sowing are recommended for management of stunt.

Disease / Zone	Resistant variety	Control
Fusarium wilt North East Plain Zone (Eastern Uttar Pradesh, Bihar, Orissa, West Bengal, Assam, Arunachal Pradesh, Mizoram, Manipur, Meghalaya, Nagaland, Tripura)North West Plain Zone (Punjab, Haryana, Himachal Pradesh, Jammu & Kashmir, Western Uttar Pradesh, North Rajasthan)Central Zone (Gujarat, Maharashtra, Madhya Pradesh, Parts of Rajasthan)South Zone (Andhra Pradesh, Karnataka, Tamil Nadu, Kerala)	Pusa 212, Haryana Chana 1, JG 315, Vijay (Phule G81-1-1), GNG 663, H 355, GNG 663, GPF 2, KWR 108, G 543, Vishal (Phule G 87207), ICC 32 (Kabuli), DCP 92-3, CSG 8962 (Karnal Chana 1), Avarodhi	Avoid sowing when temperature is high. Follow 6 years crop rotation Seed treatment with Benlate T @ 1.5 g/kg seed Soil solarization. Deep ploughing during hot summer months.
Botrytis gray mold North East Plain Zone (Eastern Uttar Pradesh, Bihar, Orissa, West Bengal, Assam, Arunachal Pradesh, Mizoram, Manipur, Meghalaya, Nagaland, Tripura) North West Plain Zone (Punjab, Haryana, Himachal Pradesh, Jammu & Kashmir, Western Uttar Pradesh, North Rajasthan)	-	Seed treatment with Carbendazim + Thiram (1:1) @ 3 g/kg seed Adopt wider spacing Intercrop chickpea with linseed. Avoid excessive irrigation

Ascochyta blight

North East Plain Zone (Eastern Uttar Pradesh, Bihar, Orissa, West Bengal, Assam, Arunachal Pradesh, Mizoram, Manipur, Meghalaya, Nagaland, Tripura) North West Plain Zone (Punjab, Haryana, Himachal Pradesh, Jammu & Kashmir, Western Uttar Pradesh, North Rajasthan)	Gaurav (H 75-35), C 235, GNG 146, BG 261	Use disease free seeds. Seed dressing with Calixin M or Thiabendazole @ 3 g/kg seed Spray the crop with Bravo 500 (Chlorothalonil) @ 3 ml /l water. Destroy diseased plant debris.
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Stunt virus

Central Zone (Gujarat, Maharashtra, Madhya Pradesh, Parts of Rajasthan)	-	Adopt close spacing. Planting when aphid vector activity is low
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Root rot

Central Zone (Gujarat, Maharashtra, Madhya Pradesh, Parts of Rajasthan) South Zone (Andhra Pradesh, Karnataka, Tamil Nadu, Kerala)	H 355	Field sanitation. Seed treatment with Captan or Thiram @ 3 g/kg seed
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In North-West Plain Zone (Punjab, Haryana, Western U.P. and Rajasthan), in blight affected areas delay the sowing of chickpea up to mid November. In Peninsular Zone (Karnataka, Tamil Nadu, Andhra Pradesh and Kerala), Sow blackgram/ greengram varieties resistant to powdery mildew in low land rice fallows

Harvesting and threshing

The crop matures within 130-140 days. After maturity the plants are pulled out or when cut with a sickle leaves become reddish brown, dry up and start shedding. The harvested plants are carted to the threshing-floor, dried for about a week and threshed by trampling them under the feet of bullocks or by beating them with sticks.

Yield

A good pure crop of chickpea gives about 1.5-2.0 yield t /ha in desi varieties but the Kabuli varieties give about 2.5-3.0 t/ha yield. The yield in mixed and intercrop depends on the plant population (All India Coordinated Pulses Improvement Project trial Source: Anonymous 2002).

Results of front line demonstrations under the All India Coordinated Pulses Improvement Project (AICPIP) during 1992-93 showed that with the component technology, the productivity of pulse crops could be considerably increased.

Effect of management technology on the productivity of legumes during 1992-93

Technology	Grain yield (t ha ⁻¹)			
	Number of demonstrations	Improved technology	Local technology	Increase in yield (%)
Weed management	3	1.76	1.57	12
Insect management	25	1.25	0.98	28

Bahl and Baldeo (1981) analyzed chickpea data of coordinated trials and mini kits in some states of northern India and found a gap of 71% between research station yield and state average yield. A range of climatic, edaphic, and biotic factors constrained the productivity of chickpea. The relative importance of each factor, however, varies from region to region due to diversity of agro ecological conditions. The trials conducted in farmer's fields by All India Co-ordinated Project for Dryland Agriculture (AICRPDA) always proved superiority of package of practices (Table 9).

Superiority of Package of Practices in on-farm trials at Hoshiarpur and Hisar

Crop (No. of years)	Package of practices (kg/ha ⁻¹)	Farmers' practice (kg/ha ⁻¹)
Hoshiarpur (6)	1245	969
Hisar (7)	1099	693

Constraint analysis**Major constraints in different states**

General Constraints are cultivation of pulses on rainfed, and marginal and sub-marginal lands; Non-availability of seeds of improved and high-yielding varieties; Untimely sowing and low seed rates; Non-adoption of improved crop production technology; Insufficient and unbalanced use of fertilizers; Low and inadequate use of phosphetic fertilizers; and least attention for timely weed control.

In an agro-economic characteristic survey (Personal communication, GR Maruti Sankar, CRIDA, Hyderabad) Contingent planning out of 864 farmers in 16-targeted districts in rainfed ecological regions of India is revealed that,

- 44, 44, 6 and 6% expressed rainfall, disease and pests, seed and credit as the most constraints No.1 for chickpea.
- The district wise data indicated that rainfall and its distribution was the main constraint for low productivity of chickpea in Anantapur (91.4 %), Kurnool (70.4 %), Buldana (55.6 %), Jalgaon (75.9 %) and Nasik (72.2 %) districts.
- It was one of the dominant constraints for low chickpea yield in Dharwad (50.0 %), Gulbarga (33.3 %), Raichur (51.9 %), and Banda (31.5 %) districts in the study.
- Insect pests were found to be a leading constraint for low yields of chickpea in Bidar (100%) district. It was one of the dominant constraints for low chickpea yield in Dharwad (46.3 %), Gulbarga (64.8 %), Raichur (48.1%), Kanpur (35.2 %), Fatehpur (25.9 %), Hamirpur (31.5 %), Nasik (24.0 %) and Narsinghpur (37.0 %).
- Disease complex was found to be the main constraint for poor performance of chickpea in Narsinghpur (61.1 %) and Guna (72.2 %). It was also one of the dominant constraints for low yields of chickpea in Kanpur (20.4 %), Fatehpur (38.9 %) and Hamirpur (29.6 %).
- Lack of improved seed was a leading constraint in Banda (40.7 %), Kanpur (33.3 %), Fatehpur (35.2 %), Hamirpur (22.2 %) and Akola (31.5 %). Water availability in Guna (25.9 %), credit in Akola (51.9 %) and labour in Buldana (27.8 %) were also found to be leading constraints for low productivity of chickpea.

Summary of soil-wise constraints

Soils	Grain (t/ha)			Constraint (% farmers' response)				
	Small (<2 ha)	Medium (2-4 ha)	Large (>4 ha)	Rainfall	Plant Protection Insects	Diseases	Seed	Others
Alluvial	1.01	1.45	1.35	8	25	25	33	-
Black	0.96	1.01	1.06	45	21	6	3	-
Overall	0.97	1.12	1.13	35	22	11	10	-

Legumes have an important role as intercrops and sequential crops in sustaining the productivity of different cropping systems. A holistic system approach is a must for maximizing the benefits from BNF in legumes. High N₂-fixing legumes and cultivars should be selected for inclusion in the cropping systems. Appropriate soil and water management practices are sowing on ridges or broad beds for protecting from water logging, using scoops for light textured soils to increase water storage. To ensure good nodulation

and N₂-fixation by legumes in cropping systems, farmers must (a) use appropriate crop management practices, such as application of phosphatic fertilizers or other deficient plant nutrients; (b) control pests and disease that may affect plant canopy and in turn photosynthate supply to roots; (c) practice N-management in soil (e.g., use of slow releasing formulations, applying N to cereals only by placement, use of organic sources); and (d) use need - based inoculations with good quality rhizobial inoculants. If returned to the soil, plant residues would help in increasing the soil organic matter content, and thereby increase the soil fertility. Through such an approach, benefits from legumes BNF can be maximized for improving or sustaining productivity of cropping system.

Prioritized cultural option for rainfed chickpea based production system

District	Prioritized Options	Avg. yield (kg/ha)	Expected yield (kg/ha)
Andhra Pradesh	Water harvesting for supplemental irrigation. Use of improved cultural practices	1026	1180 to 1231
Kurnool		723	868 to 904
Dharwad		625	750 to 781
Jhabua		723	868 to 904
Gwalior, Mandsaur, Ratlam			
Bhind, Bhopal, Chhatapur, Damoh, Datia, Dewas, Indore, Rewa, Sehore, Shajapur, Shivpuri, Ujjain		929	1068 to 1115
Ahmednagar, Aurangabad, Dhule, Pune		625	750 to 781
Akola, Amravati, Buldhana, Jalgaon		723	868 to 904
Bhilwara, Jaipur, Tonk, Udaipur		625	750 to 781
Alwar, Banswara, Bhundi, Chittorgarh, S. Madhopur		1026	1180 to 1231
Banda, Hamirpur, Jhansi		723	868 to 904
Allahabad, Ballia, Hardoi, Jalaun		929	1068 to 1115
Etawah, Fatehpur, Kanpur, Lalitpur		1026	1180 to 1231
Bhojpur	Need for extension efforts to create awareness about improved package of practices including availability of suitable cultivars	1280	1472 to 1536
Bilaspur, Durg, Raipur		614	737 to 768
Ahmedabad		489	587 to 611
P. Mahals		723	868 to 904
Bijapur, Gulbarga, Raichur		468	562 to 585
Bidar		489	587 to 611
Belgaum		614	737 to 768
Betul, Guna, Mandla, Panna, Sagar, Satna, Seoni, Sidhi, Vidisha		614	737 to 768
Hoshangabad, Jabalpur, Narsinghpur, Raisen	Utilization of surplus water through suitable on-farm water management techniques including surface drainage if necessary. Adoption of improved cultural practices	959	1103 to 1151
Nasik, Sangli, Solapur	Extension efforts are needed for awareness about improved package of practices including availability of suitable cultivars	468	562 to 585
Latur, Osmanabad, Parbhani		489	587 to 611
Nagpur		614	737 to 768
Jhalawar, Kota		489	587 to 611
Bharatpur, Dhungarpur		1280	1472 to 1536
Mirzapur		1280	1472 to 1536

Because of the sensitivity of symbiotic activity to salinity, waterlogging and drought stress, or temperature stress, monitoring the symbiosis and understanding its response to particular stresses will be mandatory before selecting appropriate symbioses for stress conditions. Most of our knowledge on the effects of stress factors on BNF comes from studies on legumes other than chickpea and pigeonpea. Hence, more studies on how these two crop plants react to the stress factors are required. *Rhizobium* strains growing as saprophytes in the soil can tolerate stress environments much better than the host legumes and the symbiosis. Also, *Rhizobium* strains tolerant to some of these stress factors have been isolated; they can also be identified more easily than tolerant host plants. Plants depending on symbiotic nitrogen are more prone to the adverse effects of drought, soil temperature, high pH, and salts than are plants fertilized with nitrogen. This suggests that identification of genotypes tolerant of these stress factors should be a first step in overcoming the adverse environmental effects. All the stress factors result in absence or distortion of root hairs, the site where rhizobia enter the host prior to establishment of the symbiosis. Hence, in selecting legume genotypes better able to tolerate stress factors, the ability to form normal root hairs should be a major consideration. A study as to why, and at which stage, the symbiosis breaks down under environmental stress is important from a practical point of view, and it may provide more information about the process itself. An important contribution may be expected from a comparative study between genotypes that differ in their capacity to establish a symbiosis under stress conditions. New niches for chickpea production are Eastern U.P., Bihar and West Bengal 0.6 mha in cotton and rice fields.

Paddy fallows form promising niche for crop diversification, soil fertility enhancement and pest management in rice based production systems. This may enhance the availability of per capita availability of pulses and balanced nutrition apart from reducing cost of production in the above production system. Satellite image analysis estimated that rice area during 1999 kharif season was about 50.4 million ha. Rice-fallow during 1999/2000 rabi season were estimated 14.29 million ha. This amounts to nearly 30% of the rice-growing area. These rice-fallows offer a huge potential niche for legumes production in this region. Nearly 82% of the rice-fallows are located in the Indian states of Bihar, Madhya Pradesh, West Bengal, Orissa, and Assam. The GIS analysis of these fallow lands has indicated that they represent diverse soil types and climatic conditions. Available soil water-holding capacity (1 m soil profile) for most of these lands ranges from 150 mm to 200 mm. If it is assumed that the soils in these lands are fully saturated during most of the rice growing season, the residual moisture left in the soil at the time of rice harvest will be sufficient to raise a short-season legume crop like chickpea. Chickpea crop may not require supplemental irrigation and contribute substantially in enriching the fertility status of these soils by fixing atmospheric nitrogen and adding organic matter. In addition they may help in sustaining the rice-based systems by breaking pest and disease incidence associated with sole rice systems. Similarly, they could enhance the microbiological activity and thereby nutrient availability of the soils following rice. Chickpea at present is not a major crop especially in the rice-fallow in Andhra Pradesh, Karnataka, Orissa, Madhya Pradesh, and Bihar. Chickpea genotypes or sowing technologies that permit establishment under high initial moisture conditions should be developed to facilitate relay planting. For chickpea production in rice-lands, ascochyta blight, botrytis grey mold, fusarium wilt, dry root rot, wet root rot, black root rot, and black root rot, and collar rot fungal diseases, and pod borer, semilooper, and bruchids insect pests needs watching.

Chickpea is one of the major grain legumes widely grown in India, and is suitable for rice-fallow of Uttar Pradesh, Rajasthan, Madhya Pradesh, Bihar, West Bengal, Assam, Orissa, Maharashtra, Gujarat, Andhra Pradesh, Karnataka, and Tamil Nadu. The average national chickpea yields have increased from 700 kg/ha in 1980-81 to 970 kg/ha in 1994-95 (Ali et al. 2000). However, chickpea area has declined by more than 1 million ha during the past 15 years (Ali et al. 2000). At present India is already facing competition from Canada, Australia, and USA apart from Mexico in the chickpea marketing. Henceforth, technology mission on pulses 2005, set the objectives of increasing productivity 790 to 936 kg/ha and diversifying into further 4 lakhs ha in tenth and eleventh five year plan periods.

POPULAR AND BOTANICAL NAMES OF SOME RAINFED CROPS

Amaranthus	<i>Amaranthus viride</i>
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
Blue panic	<i>Panicum antidotale</i>
Castor	<i>Ricinus communis</i> L.
Chilli	<i>Capsicum frutescens</i> L.
Clusterbean (Guar)	<i>Cyamopsis tetragonolobus</i> (L.) Taub
Coriander	<i>Coriandrum sativum</i> L.
Cowpea	<i>Vigna unguiculata</i> (L.) Walp
Fingermillet (Ragi)	<i>Eleusine coracana</i> (L.) Gaertn
Foxtail millet (<i>Setaria</i> , Italian millet)	<i>Setaria italica</i> Beauv
Gingelly (Sesamum, Sesame, Til)	<i>Sesamum indicum</i> L.
	<i>Sesamum orientale</i> L.
Gram (Bengalgram)	<i>Cicer arietinum</i> L.
Greengram (Moong)	<i>Vigna radiata</i> (L.) Wilczek
Groundnut (Peanut)	<i>Arachis hypogaea</i> L.
Guar (Cluster bean)	<i>Cyamopsis tetragonolobus</i> (L.) Tabu
Horsegram	<i>Macrotyloma uniflorum</i> (Lam.) Verdc
Hybrid Napier	<i>Pennisetum purpureum</i> x <i>P. typhoides</i>) F1
Indian bean (Lablab)	<i>Lablab purpureus</i> (L) Sweet
Indian rape (Torina)	<i>Brassica campestris</i> L.
Indian squash melon (Tinda)	<i>Citrulus fistulosus</i>
Italian millet (Foxtail millet, <i>Setaria</i>)	<i>Setaria italica</i> Beauv
Jowar (Sorghum)	<i>Sorghum bicolor</i> (L.) Moench
Jute	<i>Corchorus capsularis</i> L.
Kabuli gram	<i>Cicer arietinum</i> L.
Lentil (Masoor)	<i>Lens culinaris</i> Medic
Maize	<i>Zea mays</i> L.
Mesta (Rozella)	<i>Hibiscus Sabdariffa</i> L.
<i>Moth</i> (dew gram)	<i>Vigna aconitifolia</i> (Jacq.) Marechal
Mustard (Raya)	<i>Brassica juncea</i> Coss.

Napier Grass	<i>Pennisetum purpureum</i>
Niger	<i>Guizotia abyssinica</i> (L.f.) Cass
Paddy (Rice)	<i>Oryza sativa</i> L.
Peanut (Groundnut)	<i>Arachis hypogaea</i> L.
Pearlmillet (Bajra)	<i>Pennisetum americanum</i> (L.) Leeke
Peas	<i>Pisum sativum</i> L.
Pigeonpea (Arhar, Redgram, Tur)	<i>Cajanus cajan</i> (L.) Millsp.
Potato	<i>Solanum tuberosum</i> L.
Proso millet	<i>Panicum milliaceum</i> L.
Ragi	<i>Eleusine coracana</i> (L.) Gaertn
Rajgira	<i>Amaranthus viridr</i>
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.
Triticale	Triticale officinale
Urd (Blackgram)	<i>Vigna mungo</i> (L.) Hepper

GENERIC AND BRAND NAMES OF SOME PESTICIDES

Herbicides/ Weedicides

Alachlor 10G, 50% EC: Lasso (Monsanto), Alataf (Rallis)
Anilophos 30% EC: Aerozin (Agr. Evo), Sumo (Dupont), Glyphotox (AIMCO), Ricil (De'Nocil), Anilostar (Shaw 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)
Fluchloralin 45%: Basalin (BASF)
Isoproturon 75%, 50% W.P.: Nocilon (De Nocil), Rakshak (Lupin), Milron (Montari), Dhanuron (Dhanuka), Hilproturan (Hindustan Insecticides), Arelon (Agr Evo), Graminon (Novartis), Bilron (Bayer)
Metalachlor 50% EC: Duel (Novartis)
Nitrofen 8 G, 25%, 24%: Tok-E-25 (Indofil)
Oxadiazon 25% EC: Ronstar (Rhone-Poulenc)
Oxyflourfen 23.5%, 0.35 Gr: Goal (Bayer), Oxygold (Indofil)
Pendimethalin 20 & 30% EC, 5% Gr: Stomp (Cyanamid Agro), Panida (Rallis)
Simazine 50%: Tafazine (Rallis), Gesatop, Hexazine (Parry Chemicals)
Trifluralin 48%: Treflan (De'Nocil), Triflurex (Parry Chemicals)

Insecticides

Aldicarb: Temic 10 G (Rhone Poulenc)
Carbaryl: 5% DUST; 10% DUST; 4 G; 50% WP: Parryvin 50 WP (E.I.D. Parry), Dhanuvin 50 WP (Dhanuka), Killlex Carbaryl (Paushak), Hexavin (Parry Chemicals), Kildiryl (Kilpest), Agroryl (Gujarat Agro), Sevin Flo 42%, Sevin 50% WP, Sevin D, Sevidol 4:4G, Sevin 4G (Rhone Poulenc)
Carbofuran 3 G, 50% SP: Furadan 3G (Rallis), Furacarb (AIMCO), Carbocil 3G (De'Nocil), Diafuran 3G (Pesticides India), Fury (NFCL), Hexafuran (Parry Chemicals), Furatox (AIMCO), Agroduran (Gujarat Agro)
Carbosulphan 25% DS: Marshal (Rallis)
Chlorpyrifos 20 EC, 10 G, 1.5 DP: Coroban (Coromandal Indag), Blaze (Indofil), Dursban, Ruban (De'Nocil), Sulban (Sulphur Mill), Specphos 20 (Southern Pesticides), Hyban (Hyderabad Chemicals), Radar (Searle India), Nuklor 20EC (Dupont), Corocin (IOCL), Scout (AIMCO), Dhanwan 20 (Dhanuka), Durmet 20EC (Cyanamid Agro), Classic (Lupin), Starban (Shaw Wallace), Doomer (Bhaskar Agro), Hilban (Hindustan Insecticides), Tagban 20 EC (Tropical Agro), Cyphos (ICI-Zenica), Tarkash (BASF), Force (NFCL), Pyrivol (Voltas), Hexaban (Parry Chemicals), Agro-Chlore (Gujarat Agro), Chlorguard (Gharda), Tafaban (Rallis), Strike (Wockhardt), Robust (Sabero)
Cypermethrin 10 EC: Ralothrin (Rallis), Ankush (BASF), Simper (ICI-Zeneca), Hi-Power (Sulphur Mills), Spec Cyperin (Southern Pesticides), Hycyper (Hyderabad Chemicals), Cyper Top (Thakar Chemicals), Lacer (Searle India), Agro-Cyper (Gujarat Agro), Jawa (Dupont), Cypercine (IOCL), Super Killer (Dhanuka), Cypermil (Montari), Polytrin (Novartis), Cyproid (AIMCO), Challenger (Tropical Agro), Cilcord, (De'Nocil), Starcip (Shaw Wallace), Volcyper (Voltas), Cypermar (Parry Chemicals), Hilcyperin (Hindustan Insecticides),
Cypermethrin 25 EC: Cymbush (ICI-Zeneca), Ralothrin (Rallis), Cypersul (Sulphur Mills) Spec Cyperin (SPEC), Angel (Hyderabad Chemicals), Cyper Top (Thakar Chemicals), Trofy 25 EC (Searle India), Cypercine (IOCL), Challenger (Tropical Agro), Cypermil (Montari), Cyperguard (Gharda Chemicals), Polytrin (Novartis), Cyproid

(AIMCO), Clicord (De'Nocil), Colt-25 (Pesticides India), Volcyper (Voltas), Shakti (Lupin), Basathrin (BASF), Hilcyperin (Hindustan Insecticides), Cybil (Bayer), Cyrex (United Phosphorus), White Gold (Newchemi), Panther (Bhaskar Agro Chemicals), Blaze (Indofil), Super Killer (Parry Chemicals), Starcip (Shaw Wallace), Super Killer (Dhanuka), Baadha (Sabero)

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

Dichlorovos 76 EC: Nuvan (Novartis), Vapona (De'Nocil), Suchlor (Sudarshan Chemicals), Specvos (SPEC), Dicotop (Thakar Chemicals), Amidos (AIMCO), Doom (United Phosphorous), 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 Phosphorous), 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 Phosphorous), Primer (Bhaskar Agro), Tagor (Tropical Agro), Teeka (NFCL), Champ (Searle India), Hexagor (Parry Chemicals), Hilthoate (Hindustan Insecticides)

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

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

Fenvalerate 20 EC 0.4% DUST: Fenval (Searle India), Bilfen (Bayer), Starfen (Shaw Wallace), Fen-Fen (Parry Chemicals), Topfen (Thakar Chemicals), Tagfen (Tropical Agro), Trump Card (Dhanuka), Hilfen (Hindustan Insecticides), Fencron (Novartis), Sumitox (AIMCO), Fenkill (United Phosphorous), Lufen (Lupin), Starfen (Shaw Wallace), 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 (Rhône – Poulneq), Tempo (Agr Evo)

Formothion 25%: Anthio (Novartis)

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

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

Monocrotophos 36% SL: Nuvacron (Novartis), Monocil (De'Nocil), Monovol (Voltas), Atom (Indofil), Sufos (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), Lufhos (Lupin), Kadett (PesticidesIndia), Agromonark (Gujarat Agro), Moncar (Bhaskar Agro), Azodrin (Cyanamid India), Hilcron (HindustanInsecticides), Macrophos (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 India), Volphor (Volrho), Starphor (Shaw Wallace), Specphor (SPEC), Forcin (IOCL), Dhan 100 (Dhanuka), Milate (Montari), Granutox (AIMCO), Umet

(United Phosphorous), Lophate (Lupin), Agro-Phorate (Gujarat Agro), Helmet (Tropical Agro Chemicals), Warrant (Searle India), Hilphorate (Hindustan Insecticides), Grenades

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

Phosphamidon 85 S.L.: Dimecron (Novartis), Gildon (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), Ekatox (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 (Rhone-Poulenc)

Fungicides

Aureofungin 46.15% SP: Aureofungin Sol (Hindustan Antibiotics)

Captafol 80%: Foltaf (Rallis)

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

Carbendazim 50 WP, 5 Gr: Barvestin, 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 (Navartis)

Streptomycin: Streptomycin (Hindustan Antibiotics), Plantomycin (Aries Agrovat)

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

Tridemorph 80% EC: Calixin (BASF)

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

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

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

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Acronyms

a.	-	i.-active ingredient
@	-	at the rate of
CC	-	cubic centimeter
cm	-	centimeter
DAG	-	days after germination
DAP	-	days after planting
DAS	-	days after sowing
D	-	dust
EC	-	emulsifiable concentrate
ETL	-	economic threshold level
FYM	-	farm yard manure
g	-	grams
G	-	granules
gsm	-	grams per square meter
ha	-	hectare
HNVP	-	<i>Heliothis</i> Nuclear Virus Production
K ₂ O	-	pottasium
kg	-	kilogram
LE	-	larval equivalent
l	-	litre
ml	-	millilitre
m	-	metre
N	-	nitrogen
O.C	-	organic carbon
P ₂ O ₅	-	phosphate
ppm	-	parts per million
SP	-	soluble powder
S	-	sulphur
t	-	tonnes
WP	-	wettable powder
WS	-	wettable sulphur
YMV	-	yellow mosaic virus

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