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

Districtwise Promising Technologies for Rainfed Linseed 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 form 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 linseed 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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Agroindustries
• Implements • Seeds
• Fertilizers • Pesticides

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LINSEED BASED PRODUCTION SYSTEM

The oldest regions of linseed (*Linum usitassimum L.*) cultivation are reported to be in Asia and on the Mediterranean coast. Linseed is extensively grown in the countries of the temperate zone as well as in those of the tropical zone. The major linseed growing countries are Argentina, the former USSR countries, India, the USA, Canada, Pakistan and Australia. India accounts for about 1.9 million hectares, with a seed production of 4.98 lakhs of tonnes and occupies the third rank among the linseed-producing countries. Australia and Canada have the highest productivity of about 0.7 t/ha. The yield in the country is the lowest in the world. In India, the major linseed growing states are Madhya Pradesh, Maharashtra, Uttar Pradesh, Bihar, Rajasthan, Orissa, Karnataka, West Bengal, Assam, Andhra Pradesh, Himachal Pradesh, Jammu & Kashmir, Punjab and Nagaland. Madhya Pradesh and Uttar Pradesh together contribute to the national linseed production to the extent of about 70 per cent.

Linseed occupies a greater importance among oilseeds owing to its various uses and special qualities. It is grown mainly for seed used for extracting oil in rainfed conditions. The oil content of the seed varies from 33-47%. Linseed oil is an excellent dyeing oil used in manufacturing paints and varnishes, oilcloth, waterproof fabrics and linoleum and as edible oil in some areas. Linseed cake is a very good manure and animal feed. Dual-purpose linseed straw produces fibre of good quality. Linseed is also used in making paper and plastics. That is why it is also known as plastic crop.

Linseed is grown in the range of latitudes between the 10th and 65th parallels, both north and south. Its cultivation is confined to low elevations, but it can be successfully grown up to 770 m. Areas with the annual rainfall ranging from 450-750 mm are best suited for its cultivation. The seed crop does well under moderate semi-arid cold, but the fibre crop grows best in cool moist sub-humid climates. In India, the crop is grown in the *rabi* season from September-October to February-March. Linseed can be grown on different kinds of soils, except the sandy and badly drained heavy clays or clay loams. It does well on clay loams, deep clayey black soils of central and peninsular India and on the alluvium loams of the Indo-Gangetic plains.

Owing to development of improved linseed varieties and refinement of package of practices for different situations of linseed cultivation, there has been a steady but slow increase in the yield of linseed over a long period. The national yield average for the quinquennium 1981-86 was 272 kg/ha, which increased to 293 kg/ha by the next quinquennium of 1985-90. The present national average yield in 2000 is 385 kg/ha.

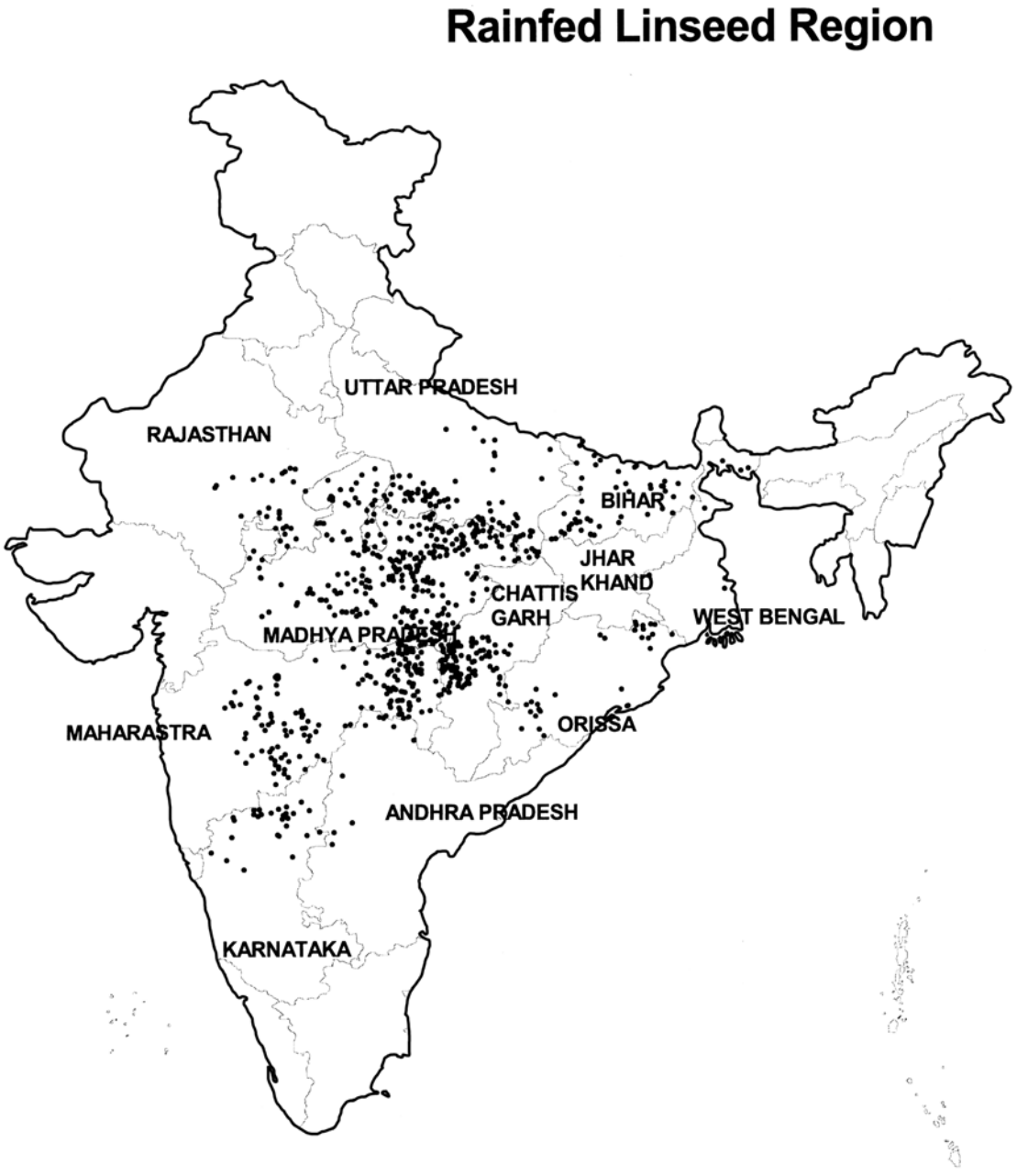
Rainfed linseed is grown in 0.82 mha in 281 districts of which 0.80 mha is under rainfed based on 1966-94 data in 16 states - Andhra Pradesh, Bihar, Jharkhand, Chattisgarh, Orissa, Madhya Pradesh, Maharastra, Gujarat, Punjab, Hisar, Uttaranchal, Uttar Pradesh, Rajasthan, Karnataka, Tamilnadu and West Bengal covering arid, semi-arid and dry sub-humid regions. About 85% of the area (0.66 mha) is grown in 42 districts.

Selection criteria	No. of districts	Area under linseed ('000 ha)	Area under rainfed linseed ('000 ha)	Gross cropped area ('000 ha)	Yield (kg/ha)
States (16)	281	823	801	149614	184
Agroecoregion**	225	803	782	120780	205
Cumulative 85% rainfed linseed area	42	675	661	25547	307

** Arid, semi arid and dry sub humid

The 42 districts of linseed production area in order of decreasing are -

1. Allahabad (Uttar Pradesh), 2. Aurangabad (Maharashtra), 3. Balaghat (Madhya Pradesh), 4. Banda (Uttar Pradesh), 5. Baran (Rajasthan), 6. Beed (Maharashtra), 7. Bhandara (Maharashtra), 8. Bijapur (Karnataka), 9. Bilaspur (Madhya Pradesh), 10. Chandrapur (Maharashtra), 11. Chhatarpur (Madhya Pradesh), 12. Damoh (Madhya Pradesh), 13. Durg (Madhya Pradesh), 14. Guna (Madhya Pradesh), 15. Hamirpur (Uttar Pradesh),


Rainfed Linseed Region
UTTAR PRADESH
RAJASTHAN
BIHAR
JHAR
KHAND
CHATTIS
GARH
WEST BENGAL
MADHYA PRADESH
MAHARASTRA
ORISSA
ANDHRA PRADESH
KARNATAKA

16. Hoshangabad (Madhya Pradesh), 17. Jabalpur (Madhya Pradesh), 18. Jalna (Maharashtra), 19. Jhansi (Uttar Pradesh), 20. Kalahandi (Orissa), 21. Kota (Rajasthan), 22. Latur (Maharashtra), 23. Lalitpur (Uttar Pradesh), 24. Mandla (Madhya Pradesh), 25. Mayurbhanj (Orissa), 26. Mirzapur (Uttar Pradesh), 27. Nagpur (Maharashtra), 28. Osmanabad (Maharashtra), 29. Panna (Madhya Pradesh), 30. Parbhani (Maharashtra), 31. Rajnandgaon (Chattisgarh), 32. Raipur (Chattisgarh), 33. Raisen (Madhya Pradesh), 34. Rewa (Madhya Pradesh), 35. Sagar (Madhya Pradesh), 36. Satna (Madhya Pradesh), 37. Sehore (Madhya Pradesh), 38. Seoni (Madhya Pradesh), 39. Shahdol (Madhya Pradesh), 40. Shivpuri (Madhya Pradesh), 41. Sidhi (Madhya Pradesh), 42. Wardha (Maharashtra)

The trends in area and yield growth rates based on statistical significance for different districts are given in the below:

Area	Yield	State	Districts
Stagnant	Increasing	Karnataka Madhya Pradesh Uttar Pradesh	Bijapur Balaghat Allahabad
Stagnant	Stagnant	Madhya Pradesh Maharashtra Uttar Pradesh	Satna, Panna, Seoni, Shahdol, Mandla, Shivpuri Bhandara Mirzapur
Decreasing	Stagnant	Madhya Pradesh Maharashtra Rajasthan	Rewa, Guna Aurangabad, Parbhani, Osmanabad, Beed, Wardha Kota
Decreasing	Increasing	Maharashtra	Durg, Bilaspur, Raipur, Hoshangabad, Sehore, Nagpur
Increasing	Increasing	Madhya Pradesh	Jabalpur, Raisen
Increasing	Stagnant	Madhya Pradesh Maharashtra Uttar Pradesh	Sagra, Damoh, Chhatarpur, Sidhi Chandrapur Hamirpur, Jhansi, Banda

All India Coordinated Research Project on Linseed (AICRPL), Kanpur, delineated linseed growing regions into three agroclimatic regions viz, North-western region (rainfed or irrigated in Punjab, Haryana, Himachal Pradesh, Jammu & Kashmir), Gangetic alluvium region (mostly irrigated in Uttar Pradesh,Bihar, Jharkhand, West Bengal and Assam) and Central, Peninsular and Southern region (mostly rainfed in Bundelkhand region of Uttar Pradesh, Madhya Pradesh, Chattisgarh, Orissa, Karnataka, Maharashtra and Rajasthan). The popular linseed production systems existing in various rainfed agroecological regions are presented below:

Agroecological region	Cropping System
Semi-arid Central highlands (Malwa) Gujarat plain and Khathiawar peninsula	Wheat+linseed
Hot Sub-humid (dry) Northen Plain	Rice-linseed Maize-linseed
Hot Subhumid (dry) Central Highlands (Malwa and Bundelkhand)	Rice- linseed
Hot Moist/ Dry Subhumid Transitional Chhatisgarh - Mahanadi basin	Rice-linseed Fallow-linseed
Hot subhumid Eastern Plateau (Chotanagpur) and eastern ghats	Rice-linseed
Hot sub-humid (moist) Eastern Plain	Rice-linseed

Details on associated crops and livestock (cluster analysis) are presented below:

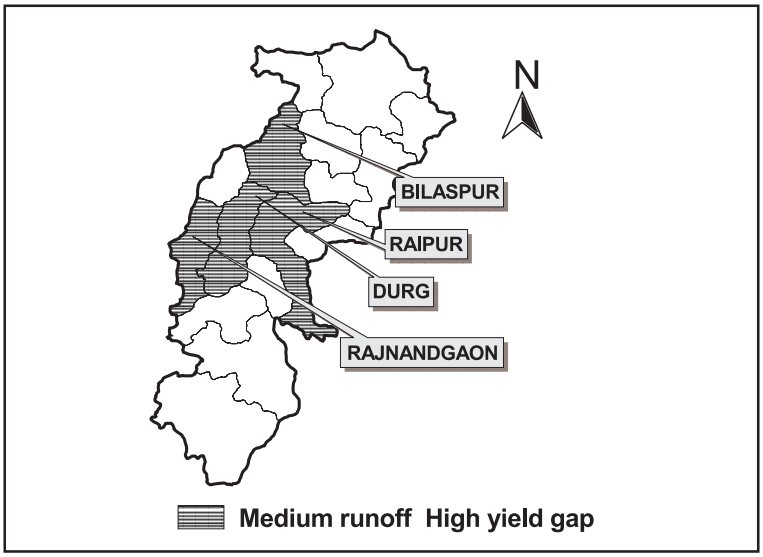
Crops	Animals	Districts
Sorghum Sunflower Sugarcane Barley Linseed Fruits Vegetables	Female Buffalo Female Cattle Male Buffalo Male Cattle Sheep Goat	Sehore, Hoshangabad, Bijapur, Aurangabad, Parbhani, Beed, Osmanabad, Wardha, Nagpur, Chandrapur, Kota, Jalna, Latur, Baran
Wheat Rice Chickpea Soybean Sorghum Lentil Linseed Vegetables Fruits	Female Buffalo Female Cattle Male Buffalo Male Cattle Sheep Goat	Jabalpur, Seoni, Sagar, Damoh, Chhatarpur, Panna, Rewa, Siddhi, Satna, Guna, Raisen, Lalitpur
Chickpea Sorghum Wheat Rice Lentil Pearlmillet Linseed Vegetables Fruits	Female Buffalo Female Cattle Male Buffalo Male Cattle Sheep Goat	Shivpuri, Allahabad, Jhansi, Hamirpur, Banda, Mirzapur
Rice Chickpea Linseed Wheat Vegetables Horsegram Greengram Soybean Lentil Fruits	Male Cattle Female Cattle Goat Male Buffalo Female Buffalo Sheep	Durg, Raipur, Bilaspur, Balaghat, Mandla, Shahdol, Bhandara, Rajnandgaon, Kalahandi, Mayurbhanj

The crops and livestock are arranged based upon decreasing area or number respectively.

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

CHATTISGARH

In Chattisgarh there are four districts viz. Bilaspur, Durg, Raipur and Rajnandagaon under medium runoff and high yield gap region.



District	Region
Bilaspur Durg Raipur Rajnandgaon	Medium runoff and high yield gap

Agroecological setting

Bilaspur

- **Climate:** Hot moist/dry sub humid
- **Physiography:** Dandakaranya (Eastern ghats)
- **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:** Dandakaranya (Eastern ghats)
- **Soils:** Deep loamy to clayey red and yellow soils (Alfisols - 60%; Ustalsf/ 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 (Ustolls- 50%; Alfisols- 25%; Vertisols- 15%)
- **Annual rainfall:** 1388 mm
- **Potential evapotranspiration:** 1723 mm
- **Moisture availability period:** 150-180 days

Rajnandgaon

- **Climate:** Hot moist / dry sub humid
- **Physiography:** Chattisgarh Mahanadi Basin
- **Soils:** Deep loamy to clayey red and yellow soils(Alfisols - 50%; Ustalfs/ Ustolls - 50%)
- **Annual rainfall:** 1354 mm
- **Potential evapotranspiration:** 1577 mm
- **Moisture availability period:** 150-180 days

Soil and water conservation

Bilaspur, Rajnandgaon

- 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 filled 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, Raipur

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- Contour farming
- Rain water 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 filed 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 run off in vertisols, which is harvested in the tank.

Crop management

Bilaspur, Durg, Raipur, Rajnandgaon

- **Varieties:** T-397, Jawahar - 7 (Utera/ Rainfed) Jawahar - 17, Jawahar - 552 (JLS (J) - 1, LC-185, Himalini

Some other important practices:

- Rice (early)- linseed
- Cowpea (fodder) - linseed
- Soybean-linseed
- Blackgram/ greengram - linseed + chickpea/ mustard
- At the time of sowing appropriate soil moisture should be ascertained in the field provide protective irrigation
- Seed treatement with Bavistin @ 1.5 g/kg of seed/ Thiram 3 g/kg of seed/ Topsin - M @ 2.5 g/kg seed

Suitable cropping system

Bilaspur, Durg, Raipur, Rajnandgaon

- Linseed + chickpea (2:1/ 3:1)
- Rice - linseed - for midland / lowland
- Soybean-linseed

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 utilized 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 M.B. 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 is efficient for field preparation during *rabi* and summer.
- **Puddlers:** Bullock drawn Agro puddler and Riding Puddler
- **Weeders:** Ambika paddy weeder for efficient weed management

Durg, Raipur, Rajnandgaon

- Seed cum ferti drill

Alternate farming systems

Bilaspur, Raipur

- **Agri horti system:** Mango + pea/ berseem (green fodder)/ wheat/ chickpea/ soybean (Inter cropping of ginger, okra, cowpea, groundnut, soybean, blackgram and pigeonpea was are recommended in mango orchard plantation)
- **Silvi pastoral system:** Teak + sudan grass The multipurpose tree species with fast growth rate are Khamhar (*Gmelina arborea*), Shisham,*Dalbergta sissoo*), Poplar (*Populus deltoides*), Bakain, Casuarina spp., Archasia spp. *Cassia siamea* and Acacia sp. Poplar (*Populus deltoides*), Shisham (*Daldergia sissoo*), Shisham (*Daldergia sissoo*), Shisham (*Daldergia sissoo*), Khamhar (*Gmelina arborea*) and Siris (*Albeizia lebbeck*) are recommended for silviculture

- **Fodder/ green biomass:** *Leucaena leucocephala, Albizzia amara, Dichrostachys cineria, Melia azadirach, Hardwickia binata, A.lebbeck*
- **Fruits:** Mango, ber, guava, tamarind, karonda
- **Medicinal and aromatic plants:** *Safed musli, Palma rosa, Withania somnifera, Papaver somniferum,Vetiveria zyzanoides*
- **Vegetables:** Brinjal, chilli, cowpea, okra, bottle gourd, round melon.
- **Horticulture:** Promising mango varieties recommended for different purposes are as follows:
  - Langra - Banarasi, Desheri, Bombay Green (Table varieties) Rani Pasand (Sucking) Batasiya & 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.
- **Animal component:** Female and male cattle, female buffaloes, goats

Durg, Rajnandgaon

- **Fodder/green biomass:** *Albizzia lebbeck, 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, Amaranth, Drumstick
- **Horticulture:**
  - Promising mango varieties recommended for different purposes are as follows:
    - **Table varieties:** Langra - Banarasi, Desheri, Bombay Green
    - **Sucking:** Rani Pasand
    - **Pickle & *murabba:*** Batasiya & Karela
- **Agro-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.
- **Animal component:** Female Cattle, Male Cattle, Female Buffaloes, Male Buffaloes

Contingent planning

Bilaspur, Durg, Raipur, Rajnandgaon

June

- **Sole crop**
  - Sorghum (CSH 6, JS 1041)
  - Greengram (K 850)
  - 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 6)
  - Pigeonpea (NPWR -15, JA4, Asha)
  - Groundnut (Jyoti, M 12, Exotic 1-1)
- **Inter crop**
  - Sorghum + pigeonpea (2:1)
  - Soybean + pigeonpea (2:1)

August

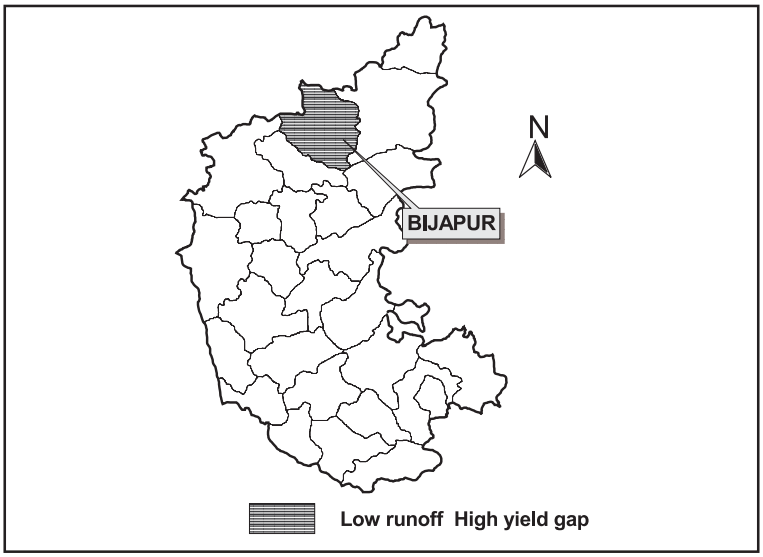
- Castor (GCH 4, other hybrids)
- Pigeonpea (No.148)

October

- Wheat (JW 17, C 306)
- Chickpea (JG 321, JG 315)
- Linseed (JL 23, R 552)
- Barley (Karan 4, Jyoti)
- Lentil (JL 1, Malika)

KARNATAKA

In Karnataka there is one district viz. Bijapur with low runoff and high yield gap.



District	Region
Bijapur	Low runoff and high yield gap

Agroecological setting

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

Soil and water conservation

- Rubbles at 0.3 m vertical interval on contour key lines
- Planting Khus grass and *Leucaena leucocephala* in paired rows at vertical interval of 0.3 m Bund stabilisation through *Sylosantnes sp.*
- Bund planting with neem, sissoo and tamarind
- A farm pond of 150 m^3 capacity for every one hectare catchment area to harvest excess runoff in medium to deep black soils
- Insuit moisture conservation practices like compartment bunding, ridges and furrows contour cultivation and fall ploughing helped to conserve more moisture in deep black soils

Crop management

- **Varieties:** Jawahar-23, Kiran, Sheetal and LMH-62
- **Planting pattern:** 25 cm
- **Seed rate:** 25 to 30 kg
- **Nutrient management:** 40 kg N + 25 kg P_2O_5

Some other important practices:

- **Sowing time:** upto 1st fortnight October
- Blackgram/ greengram - linseed + chickpea/ mustard
- Linseed + safflower
- At the time of sowing appropriate soil moisture should be ascertained in the field to provide protective irrigation
- Seed treatement with Bavistin @ 1.5 g/kg of seed/ Thiram 3 g/kg of seed/ Topsin -M@ 2.5 g/kg seed

Suitable cropping systems

- Linseed + chickpea (2:1/ 3:1)

Farm implements/ tools

- **Wooden plough (Bullock drawn):** Shallow ploughing to a depth of 10 cm. Rs2000/-
- **MB Plough (Bullock drawn):** Deep ploughing Rs.4000/-
- **MB Plough (Tractor drawn):** Deep ploughing Rs.15000/-
- **Blade harrow (Bullock drawn):** Harrowing Rs.15000/-
- **Blade harrow (Tractor drawn):** Harrowing Rs.10000/-
- **Seed cum fertilizer drill** (Bullock drawn): For sowing and fertilizer application.Rs.2500/-
- **Seed cum fertilizer drill** (Bullock drawn-adjustable): For 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/**-**
- **Silt hoe:** Hoeing operation. Rs.500/-
- **Blade hoe:** Intercultivation operations. Rs.500/-
- **Wooden float:** Clod breaking. Rs.600/-
- **Buck scraper:** For levelling. Rs.500/-
- **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/-

Alternate farming systems

- Agave (*Agave sisolana* with 10, 000 plants /ha) intercropped with Leucaena leucocephala. Cutting of agave leaves once in a year for fibre extraction with retaining top ten leaves
- Silviculture on shallow black soils*: Casuarina, Dalbergia sissoo, Hardwickia binata, Acacia nilotica, Prosopis cineraria*
- **Marginal lands:** *Dalbergia sissoo*, Neem, *Acacia nilotica*, *Leucaena leucocephala*
- **Alley cropping:** *Leucaena leucocephala*/ *Casuarina* + *kharif* crops
- **Agri- 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, Albizzia lebbeck, Hardwickia binata, Cassia siamea and Azadirachta indica*
- **Fruits:** Mango, Pomegranate, Sapota, Ber, Jamun, Tamarind
- **Medicinal**/ **Aromatic Plants:** *Cassia angustifolia, Catharanthus roseus, Palmarosa, Vetiveria zizanoides,* Rose, Geranium
- **Vegetables:** Onion, Brinjal, Chillies, Cowpea, Cucumber, Clusterbean, Drumstick
- **Animal component:** Male/ female cattle, female buffaloes, sheep, goat, poultry

Contingent crop planning

Normal onset of monsoon favourable for *Kharif* crops

- Take up sowing of the following crops in June in light soils. Groundnut (erect and spreading), pearlmillet, pigeonpea, Kharif, *setaria*, hybrid sorghum and other crop mixtures like *Kharif* sorghum + pigeonpea (2:1), groundnut + pigeonpea (4:2), setaria + pigeonpea (2:1) and pearlmillet + 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 pearlmillet, sorghum for rejuvenation after rains.
- For crops like groundnut, take up urea spray (2% solution) immediately after rains for quick revival.
- When the sown crops completely wither, plant setaria, dolichos, horsegram, *matki*, cowpea and sunflower soon after revival of rains.

No normal rains in June but onset of rains in July

- Sow groundnut (spreading), hybrid pearlmillet, 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 of dryland cotton before the middle of August. Grow *herbaceum* cottons in place of *Hirsutums*. 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 fertilizers. Fertilizers may be applied at appropriate growth stage having optimum moisture condition.

Sowing in October

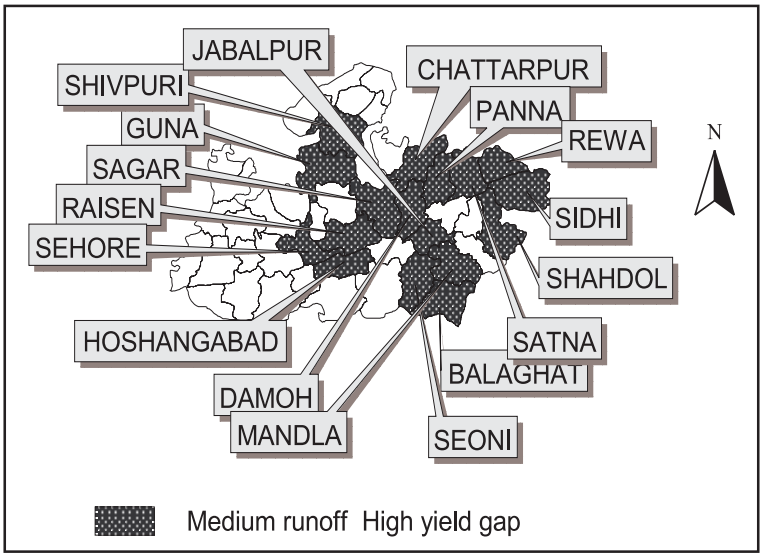
- Continue the sowing *rabi* sorghum till October 15th with 50 per cent recommended level of fertilizer.
- Follow mixed cropping of *rabi* sorghum + chickpea in (2:1).
- Sow *rabi* sorghum and chickpea as mixed crops (random mixing).
- Increase the area under safflower.
- Sow chickpea and safflower (4:2 or 3:1) 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 seventeen districts viz., Balaghat, Chattarpur, Damoh, Guna, Hoshangabad, Jabalpur, Mandla, Panna, Raisen, Rewa, Sagar, Satna, Sehore, Seoni, Shahdol, Shivpuri and Sidhi with medium runoff and high yield gap.



District	Region
Balaghat	Medium runoff and high yield gap
Chattarpur	
Damoh	
Guna	
Hoshangabad	
Jabalpur	
Mandla	
Panna	
Raisen	
Rewa	
Sagar	
Satna	
Sehore	
Seoni	
Shahadol	
Shivpuri	
Sidhi	

Agroecological setting

Balaghat

- **Climate:** Hot moist sub humid
- **Physiography:** Satpura ranges (Central highlands)
- **Soils:** Shallow to deep loamy to clayey mixed red and black soils (Vertic Inceptisols-85%; Vertisols-15%)

- **Annual rainfall:** 1474 mm
- **Potential evapotranspiration:** 1419 mm
- **Moisture availability period:** 180-210 days

Chattarpur

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

Damoh

- **Climate:** Hot dry sub humid
- **Physiography:** Vindhyan scarplands (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:** 120-150 days

Guna

- **Climate:** Hot moist semi arid to hot dry sub humid
- **Physiography:** Vindhya 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:** 120-180 days

Hoshangabad

- **Climate:** Hot dry sub humid
- **Physiography:** Narmada valley
- **Soils:** Medium and deep clayey black soils, shallow loamy black soils (Vertic Inceptisols - 100%)
- **Annual rainfall:** 1385 mm
- **Potential evapotranspiration:** 1597 mm
- **Moisture availability period:** 150-180 days

Jabalpur

- **Climate:** Hot dry/ moist sub humid
- **Physiography:** Narmada valley
- **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

Mandla

- **Climate:** Hot moist sub humid
- **Physiography:** Satpura ranges (Central highlands)
- **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:** Baghelkhand plateau (Central highlands)
- **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

Raisen

- **Climate:** Hot dry sub humid
- **Physiography:** Narmada valley
- **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

Rewa

- **Climate:** Hot dry sub humid
- **Physiography:** Vindhyan scarplands/ Malwa plateau
- **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

Sagar

- **Climate:** Hot moist semi arid/ Hot dry sub humid
- **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:** 120-180 days

Satna

- **Climate:** Hot dry sub humid
- **Physiography:** Baghelkhand 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

Sehore

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

Seoni

- **Climate:** Hot moist sub humid
- **Physiogrpahy:** Satpura ranges/ 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

Shahadol

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

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

Sidhi

- **Climate:** Hot dry sub humid
- **Physiography:** Baghelkhand 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

Soil and water conservation

Balaghat

- Sowing across the slope
- Contour farming

Mandla

- Bench terracing, compartment bunding, graded border strips, sowing across the slope and ridging later

Guna, Hoshangabad, Raisen, Sagar, Sehore, Seoni

- 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 watershed area to use stored water for irrigation purpose.
- Silpaulin (plastic material) of 90 - 120 gsm has been found effective lining material for farm ponds used for water harvesting purposes.
- Use vegetative barriers to strengthen the mechanical bunds at suitable vertical intervals in order to reduce run off in associated soil losses from the cultivated fields.
- Develop a sort of terracing; break the continuity of undulating slope to reduce the chances of degrading cultivated fields in to gully.

- Ensure drainage line treatment for providing safe disposal of excess run off and providing more opportunity time in order to reduce erosive velocity.
- Mould board plough, used for deep tillage to increase the productivity of *kharif* crops and enhance sowing of *rabi* crops through better moisture conservation and eradication of infested weeds.
- Graded bunds alone and / or along with vegetative barriers at vertical intervals of 50 cm proves most effective in controlling soil erosion and nutrient losses on soils having slope up to 2 per cent.
- Off-season shallow tillage is important not only in controlling the weeds but also in helping entry of 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.

Chattarpur, Damoh, Jabalpur, Panna, Rewa, Satna, Shahadol, Sidhi

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

Shivpuri

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

Crop management

Balaghat, Chattarpur, Damoh, Jabalpur, Mandla, Panna, Seoni

- **Varieties:** T-397, Jawahar - 7 (Utera/ Rainfed) Jawahar - 17, Jawahar - 552 (JLS (J) - 1), Padmini, JLS-9, J-23, T-397, R-552, Kiran, Sheetal, Triveni, Jawahar-23, LMH-62, RL-993, Jawahar-1
- **Seed rate:** 25 to 30 kg
- **Planting pattern:** 25 cm
- **Nutrient management** 35 + 15 kg P_2O_5/ha
- **Some other important practices:**
  - Rice (early)- linseed
  - Cowpea (fodder)-linseed
  - Soybean-linseed
  - Blackgram/ greengram - linseed + chickpea/ mustard
  - Linseed + safflower
  - Time of sowing: first fortnight October

- At the time of sowing appropriate soil moisture should be ascertained in the field provide protective irrigation
- Seed treatement with Bavistin @ 1.5 g/kg of seed/ Thiram 3 g/kg of seed /Topsin - M @ 2.5 g/kg seed

Guna, Shivpuri

- **Varieties:** T-397, Hira, RR 9, Kiran, Sheetal, Padmini, JLS-9, J-23, T-397, R-552, Triveni, Jawahar-23, LMH-62, RL-993, Jawahar-1
- **Seed rate:** 25 to 30 kg
- **Planting pattern:** 25 cm
- **Nutrient management**
  - Seed inoculation of linseed with Azatobacter + 100% recommended dose + 5 t FYM
  - 40 kg N + 20 kg P_2 O_5 /ha
- **Some other important practices:**
  - Line sowing
  - Rice (early)- linseed
  - Cowpea (fodder)-linseed
  - Soybean-linseed
  - Blackgram/ greengram - linseed + chickpea/ mustard
  - Linseed + Safflower
  - Time of sowing: first fortnight October
  - At the time of sowing appropriate soil moisture should be ascertained in the field provide protective irrigation
  - Seed treatement with Bavistin@1.5 g/kg of seed/ Thiram 3 g/kg of seed /Topsin - M @ 2.5 g/kg seed

Hoshangabad, Raisen, Sagar, Sehore

- **Varieties:** Kiran, Sheetal, R-552, J-23, T-397, Jawahar - 7 (Utera/ Rainfed), Jawahar - 17, Jawahar - 552 (JLS (J) - 1, Padmini, JLS-9, J-23, T-397, R-552, Triveni, Jawahar-23, LMH-62, RL-993, Jawahar-1
- **Seed rate:** 20 - 25 kg/ha
- **Planting pattern:** 30 x 5 cm
- **Nutrient management** 40 kg N + 40 kg P_2O_5 + 20 kg K_2O + 20 kg S/ha
- **Some other important practices:**
  - Sowing in mid September to mid october
  - Rice (early)- linseed
  - Cowpea (fodder)-linseed
  - Soybean-linseed
  - Blackgram/ greengram - linseed + chickpea/ mustard
  - Linseed + Safflower
  - Time of sowing: first fortnight October
  - At the time of sowing appropriate soil moisture should be ascertained in the field provide protective irrigation
  - Seed treatement with Bavistin @ 1.5 g/kg of seed/ Thiram 3 g/kg of seed /Topsin - M @ 2.5 g/kg seed

Rewa, Satna, Shahadhol, Sidhi

- **Varieties:** T-397, Jawahar - 7 (Utera/ Rainfed) Jawahar - 17, Jawahar - 552 (JLS (J) - 1), Kiran, T-397, R-552, Sheetal, Triveni, Jawahar-23, LMH-62, RL-993, Jawahar-1, Padmini, JLS-9, J-23
- **Seed rate:** 25 to 30 kg
- **Planting pattern:** 25 cm
- **Integrated Nutrient management** 40 kg N + 30 kg $P_2 0_5$ /ha.
- **Some other important practices:**
  - The fertilizer should be applied at sowing, preferably with Dufan (seed cum fertilizer drill below the seed)
  - Sowing in the last week of September and in the first week of October
  - Rice (early)- linseed
  - Cowpea (fodder)-linseed
  - Soybean-linseed
  - Blackgram/ greengram - linseed + chickpea/ mustard
  - Linseed + Safflower
  - Time of sowing: first fortnight October
  - At the time of sowing appropriate soil moisture should be ascertained in the field provide protective irrigation
  - Seed treatement with Bavistin@1.5 g/kg of seed/ Thiram3 g/kg of seed / Topsin - M @ 2.5 g/kg seed

Suitable cropping system

Balaghat, Seoni

- Linseed + chickpea (2:1/ 3:1)
- Rice - linseed - for midlands to lowlands

Chattarpur, Damoh, Jabalpur, Panna, Rewa, Satna, Shahadol, Sidhi

- Linseed + chickpea (2:1/ 3:1)

Hoshangabad, Raisen, Sagar, Sehore

- Linseed + chickpea (2:1/ 3:1)
- Soybean - linseed

Shivpuri

- Linseed + chickpea (2:1/ 3:1)
- Wheat + linseed - for medium black soils
- Chickpea + linseed - for mixed red and black soils

Farm implements/ tools

Hoshangabad, Raisen, Sagar, Sehore

- Suitable implements for seedbed preparations
- Meston Plough
- Iron Bakhar
- Suitable implements for sowing operations

- Mahakal Dufan
- Mahakal Tifan
- Sarta attachment for intercropping
- Suitable implements / tools for interculture operations
- Hand dora (small blade harrow)
- Bullock drawn dora (small blade harrow with wooden beam)
- Indore ridger

Suitable implements may be selected from above in case of non-availability of location specific implements for other districts

Alternate farming systems

Balaghat

- Alley cropping - *Leucaena leucocephala* (4 m interval) + ground nut/sesamum/cowpea (grain)
- **Fodder/green biomass:** *Albizzia lebbeck, 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
- **Horticulture**
  - Promising mango varieties recommended for different purposes are as follows:
  - Langra - Banarasi, Desheri, Bombay Green - Table varieties
  - Rani Pasand - Sucking
  - Batasiya & 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.
- **Animal component:** Cattle, Buffaloes

Seoni

- Alley cropping - Leucaena leucocephala (4 m interval) - + ground nut/ sesamum/ cowpea (grain)
- **Fodder/green biomass:** *Albizzia lebbeck, 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:** Cattle and buffaloes

Damoh, Mandla

- **Agro-hortisystem:** Mango + pea/ berseem (green fodder)/ wheat/ chickpea/ soybean; Mango/ guava/ amla+ field crops (wheat, barley, pulses and oilseeds)
- Alley cropping - *Leucaena leucocephala* (4 m interval) + ground nut/ sesame/ cowpea (grain)
- **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, ridge gourd, amaranthus, drumstick
- **Animal component:** Cattle, buffaloes

Shivpuri

- **Agro - hortisystem:** Mango + Pea / Berseem (green fodder) / Wheat/ chickpea / soybean
- **Silvi - pastoral system:** Teak + Sudan grass
- **Fodder/green biomass:** *Leucaena, Melia azadirach,* ***Dichrostachys*** *cinerarea, Albizzia amara, A.lebbeck, Hardwickia binata, A.nilotica*
- Ley farming - Four years continuous raising of *Stylosanthes hamata* followed by sorghum
- **Fruits:** *Emblica officinalis* (amla), Guava, Ber, Mango
- **Medicinal and aromatic plants:** *Rauvolfia serpentina, Vetivera zyzanoides,* Palmarosa, Safed musli, Ashwagandha
- **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, Goats and Poultry

Guna

- **Fodder/ green biomass:** *Dichrostachys cineria, Albizzia amara, Faidherbia albida, Harwickia binata, Cassia, Leucaena leucocephala, Albizzia lebbeck*
- **Fruits:** Ber, Pomegranate, Mango, Fig, Tamarind
- **Medicinal/ Aromatic Plants:** *Withamnia somnifera, Rauvolfia serpentina, Vetiveria zyzanoides, Palmarosa, Liquorice.*
- **Vegetables:** Chillies, Okra, Watermelon, Cowpea, Cluster bean, Amaranth, round melon.
- **Animal Component:** Male/ female cattle, female buffaloes, sheep, goat, dairy

Hoshangabad, Sagar, Sehore, Raisen

- **Agrihortisystem:** Mango + pea / berseem (green fodder) / wheat/ chickpea / soybean
- **Silvi pastoral system:** Teak + Sudan grass
- **Fodder/ green biomass:** *Dichrostachys cineria, Albizzia amara, Faidherbia albida, Hardwickia binata, Cassia, Leucaena leucocephala, Albizzia lebbeck*
- **Fruits:** Ber, Pomegranate, Mango, Fig. Tamarind
- **Medicinal/ Aromatic Plants:** *Withamnia somnifera, Rauvolfia serpentina, Vetiver zyzanoides,* Palmarosa, *Liquorice.*
- **Vegetables:** Chillies, Okra, Watermelon, Cowpea, Cluster bean, Amaranthus, Round melon.
- **Animal component:** Male/ female cattle, female buffaloes, sheep, goat, dairy

Chattarpur, Jabalpur, Panna, Rewa, Satna, Sidhi

- **Agro - hortisystem:** 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, Albizzia amara, Dichrostachys cineria, Melia azadirach, Hardwickia binata, A.lebbeck*
- **Fruits:** Mango, Ber, Guava, Tamarind and Karonda
- **Medicinal and aromatic plants:** *Safed musli,* Palmarosa*, Withania somnifera, Papaver somniferum, Vetiveria zyzanoides*
- **Vegetables:** Brinjal, Chilli, Cowpea, Okra, Bottle gourd, Round melon
- **Animal component:** Female/ male Cattle, Female Buffaloes, Goats

Shahdhol

- **Fodder/ green biomass:** *Leucaena leucocephala, Albizzia amara, Dichrostachys cineria, Melia azadirach, Hardwickia binata, A.lebbeck*
- **Fruits:** Mango, ber, guava, tamarind, karonda
- **Medicinal/ Aromatic Plants:** *Safed musli, Palmarosa, Withania somnifera, Papaver somniferum, Vetiveria zizanoides*
- **Vegetables:** Brinjal, chilli, cowpea, okra, bottle gourd, round melon
- **Animal component:** Female cattle, male cattle, female buffaloes, goats

Contingent planning

Balaghat, Chattarpur, Damoh, Jabalpur, Mandla, Panna, Rewa, Satna, Seoni, Shahadol, Sidhi

June

- **Sole crop**
  - Sorghum (CSH 6, JS 1041)
  - Greengram (K 850)
  - 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)
  - Pigeonpea (NPWR -15, JA4, Asha)
  - Groundnut (Jyoti, M 12, Exotic 1-1)
- **Intercrop**
  - Sorghum + pigeonpea (2: 1)
  - Soybean + pigeonpea (2: 1)

August

- Castor (GCH 4, Varuna etc.)
- Pigeonpea (No.148)

October

- Wheat (JW 17, C 306)
- Chickpea (JG 321, JG 315)
- Linseed (JL 23, R 552)
- Barley (Karan 4, Jyoti)
- Lentil (JL 1, Malika)

Hoshangabad, Raisen, Sagar, Sehore, Guna

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

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

Shivpuri

Kharif

Under normal rainfall

- Pearlmillet (Proagro 9402), pigeonpea (UPAS 120), greengram (K 851), clusterbean (RGC 197)

Rainfall upto end of July

- Cereals and pulses: Pearlmillet (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 pearlmillet (MBH 163)

Rainfall upto end of August

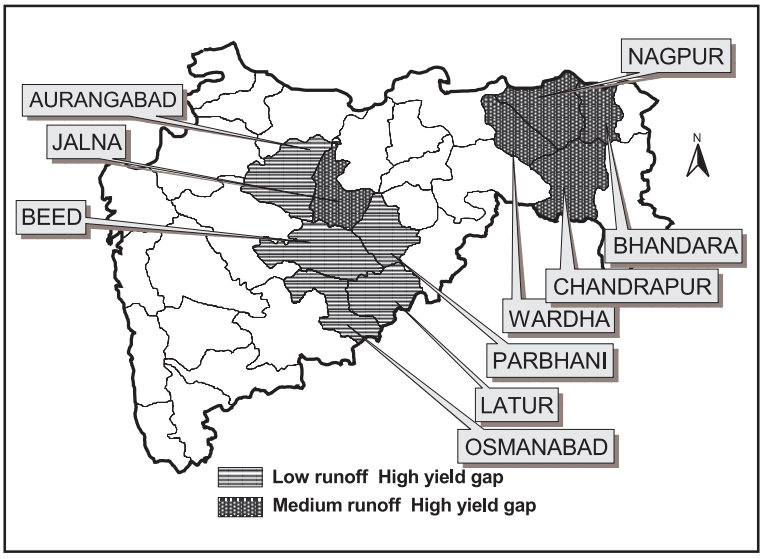
- Clusterbean as pure crop (RGC 197)
- Castor with a seed rate of 15 kg/ha.

Rabi

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

MAHARASHTRA

In Maharashtra there are five districts viz. Aurangabad, Beed, Latur, Osmanabad and Parbhani under low runoff and high yield gap region nad five districts viz., Bhandara, Chandrapur, Jalna, Nagpur and Wardha with medium runoff and high yield gap.



District	Region
Aurangabad Beed Latur Osmanabad Parbhani	Low runoff and high yield gap

Agro-geographic setting

Agroecological setting

Aurangabad

- **Climate:** Hot semi arid
- **Physiogrpahy:** 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

Beed

- **Climate:** Hot dry semi arid
- **Physiography:** Western Maharashtra Plateau

- **Soils:** Shallow and medium loamy black soils, deep clayey black soils (Vertic Inceptisols - 100%)
- **Annual rainfall:** 685 mm
- **Potential evapotranspiration:** 1606 mm
- **Moisture availability period:** 90-120 days

Latur

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

Osmanabad

- **Climate:** Hot moist semi arid
- **Physiography:** South Western Maharashtra Plateau
- **Soils:** Shallow and medium loamy black soils, deep clayey black soils (Vertic Inceptisols - 100%)
- **Annual rainfall:** 809 mm
- **Potential evapotranspiration:** 1984 mm
- **Moisture availability period:** 90-120 days

Parbhani

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

Soil and water conservation

Aurangabad, Beed, 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

Crop management

Aurangabad, Beed, Latur, Osmanabad, Parbhani

- **Varieties:** C-429, LC-185, Himalini, Kiran, Sheetal, Padmini, NL-97, Jawahar-23, LMH-62
- **Seed rate:** 30 kg/ha
- **Planting pattern:** 25 cm
- **Nutrient management** 40 kg N + 20 kg P_2O_5/ha
- **Some other important practices:**
  - Blackgram/ greengram - linseed + chickpea/ mustard
  - Linseed + safflower
  - Sowing - first fortnight October
  - At the time of sowing appropriate soil moisture should be ascertained in the field provide protective irrigation
  - Seed treatement with bavistin @ 1.5 g/kg of seed/ thiram 3 g/kg of seed/ Topsin - M @ 2.5 g/kg seed

Suitable cropping systems

Aurangabad, Beed, Latur, Osmanabad, Parhbani

- Linseed + safflower (3:1)
- Linseed + chickpea (3:1)

Farm implements/ tools

Aurangabad, Parbhani

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

Beed, Latur, Osmanabad

- **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.** 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, pearlmillet, pigeonpea etc. and identified for sowing of the crops of dryland region. Rs.9000/-

Alternate farming systems

Beed, Latur, Parbhani

- **Agri-horticultural system:** Ber (5x5 m) + mothbean (8 lines) (30x10 cm)
- **Silvipasture:** *Leucaena* + Marvel -8
- **Alley cropping:** Ber (20 m alleys) + pearlmillet + pigeonpea for shallow soils
- **Fodder:** Maize (African Tall) Oats (Kent), *Stylosanthes hamata*
- **Fodder/ green biomass:** *Alianthus excelsa, Albizzia lebbek, Dalbergia sissoo, Azadirachta indica, Prosopis cineraria*
- **Fruits:** Ber, Date palm, Jamun, Fig, Phalsa, Karonda
- **Medicinal / aromatic plants:** *Plantago orata, Cassia angustifolia,* Safed musli*, Papaver somniferum*
- **Vegetables:** Clusterbean, cowpea, amaranthus, round melon, long melon
- **Animal component:** Female buffaloes, sheep, goat

Aurangabad, Osmanabad

- **Fodder/green biomass:** Stylo sole and stylo-marvel pastural system recorded higher green fodder yield than sole or combination of grasses.
- *Leucaena leucocephala, A.lebbeck, D.sissoo, A.indica, A.procera, Gliricidia*
- **Fruits:** Ber agro-horticulture system (ber + short duration Legume crop) was found more remunerative than anola and custard apple horticulture system.
  - Pomegranate, ber, mango, sapota, guava, tamarind
- **Medicinal & Aromatic Plants:** *Solanum viarum, Catharanthus roseus, Palmarosa, Vetiveria zyzanoides, Ocimum viride*
- **Vegetables:** Onion, chilli, brinjal, okra, amaranthus, bottlegourd.
- **Animal Component:** Female Cattle, Male Cattle, Female Buffaloes, Goat, Poultry

Aurangabad, Osmanabad

- Crop planning as per soil depth

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

Alternate land use system

Aurangabad, Beed, Latur, Osmanabad, Parbhani

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

Contingent planning

Aurangabad, Beed, Latur, Osmanabad, Parbhani

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

- **Second fortnight of June:** All *Kharif* crops
- **First fortnight of July:**
  - Pearlmillet, setaria, groundnut, castor, pigeonpea, horsegram
  - Intercropping of pearlmillet + 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, pearlmillet (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

District	Region
Bhandara Chandrapur Jalna Nagpur Wardha	Medium runoff and high yield gap

Agroecological setting

Bhandara

- **Climate:** Hot moist sub humid
- **Physiography:** Wainganga valley (Central highlands)
- **Soils:** Shallow to deep loamy to clayey mixed red and black soils (Vertic Inceptisols-75%; Vertisols-25%)
- **Annual rainfall:** 1349 mm
- **Potential evapotranspiration:** 1638 mm
- **Moisture availability period:** 180-210 days

Chandrapur

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

Jalna

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

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%; Inceptisols-20%; Entisols-20%)
- **Annual rainfall:** 1242 mm
- **Potential evapotranspiration:** 2050 mm
- **Moisture availability period:** 150-180 days

Wardha

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

Soil and water conservation

Bhandara, Chandrapur, Nagpur, Wardha

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

Jalna

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

Crop management

Bhandara, Chandrapur, Jalna, Nagpur, Wardha

- **Varieties:** C -429, LC-185, Himalini, Kiran, Sheetal, Padmini, NL-97, Jawahar-23, C-429, LMH-62
- **Seed rate:** 30 kg/ha
- **Planting pattern:** 25 cm
- **Integrated nutrient management:** 40 N + 20 kg P_2O_5/ha

Some other important practices:

- Blackgram/ greengram - linseed + chickpea/ mustard
- Linseed + safflower
- Sowing - first fortnight of October
- At the time of sowing appropriate soil moisture should be ascertained in the field provide protective irrigation
- Seed treatement with Bavistin @ 1.5 g/kg of seed/ Thiram 3 g/kg of seed / Topsin - M @ 2.5 g/kg seed

Suitable cropping systems

Bhandara, Chandrapur, Jalna, Nagpur, Wardha

- Linseed + safflower (3:1)
- Linseed + chickpea (3:1)

Farm/ implements tools

Bhandara, Chandrapur, Nagpur, Wardha

- **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.

Jalna

- **Tractor multicrop planter.** Sowing of *rabi* sorghum was done on farmer's field. Minor modifications made in the original design for adoption of the machine in dryland region. Awareness was created amongst the farmers by conducting demonstrations on farmer's field. Rs.22800/-
- **Bullock drawn Jyoti Planter.** 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 for ploughing and identified for ploughing operations in dryland region. Rs 18500/-
- **Tractor drawn:** Double bottom reversible plough 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 conervation practices like ridges and furrows and compartment bunding. Rs.2500/-
- **Kopergaon bullock drawn two-bowlseed drill.** The local made seed drill named "Kopergaon seed drill" is operated on the field for sowing crops like sorghum, pearlmillet, pigeonpea etc. and identified for sowing of the crops of dryland region. Rs.9000/-

Alternate farming systems

Bhandara, Chandrapur

- **Fodder/ green biomass:** Stylo sole and stylo-marvel pastural system recorded higher green fodder yield than sole or combination of grasses, *Leucaena leucocephala, A.lebbeck, D.sissoo, A.indica, A.procera, Gliricidia*
- **Fruits:** Ber based agro-horticulture system (Ber+short duration Legume crop) was found more remunerative than anola and custard apple horticulture system. Others Pomegranate, Ber, Mango, Sapota, Guava, Tamarind
- **Medicinal and aromatic plants:** *Solanum viarum, Catharanthus roseus,* Palmrosa, *Vetiveria zyzanoides, Oscimum viride*
- **Vegetables:** Onion, Chilli, Brinjal, Okra, Amaranthus, Bottlegourd
- **Animal component:** Female Cattle, Male Cattle, Female Buffaloes, Goat, Poultry

Jalna

- **Agri-hortisystem:** Ber (5x5 m) + mothbean (8 lines) (30x10 cm)
- **Silvipasture:** Leucaea + Marvel -8
- **Alley cropping:** Ber (20 m alleys) + pearlmillet + pigeonpea for shallow soils
- **Fodder:** Maize (African Tall), Oats (Kent), *Stylosanthes hamata*
- **Fodder/ green biomass:** *Alianthus excelsa; Albizzia lebbek, Dalbagia sissoo, Azardirachta indica, Prosopis cineraria*
- **Fruits:** Ber, Date palm, Jamun, Fig, Phalsa, Karoda

- **Medicinal / aromatic plants:** *Plantago orata, Cassia angustifolia,* Safed musli, *Papaver somniferum*
- **Vegetables:** Clusterbean, Cowpea, Amaranthus, Round melon, Longmelon
  - Lands < 22.5 cm depth of soil should be cultivated with agroforestry and dryland horticulture including Ber, Custard apple, amla, wood apple, jambhul etc.
  - On light soils Ber cultivation at 20x5 m spatial arrangement associated with pearlmillet + pigeonpea (2:1) intercropping within two rows of ber plantation was recommended.
  - Silvipastoral system of *Leucaena leucocephala* + Marvel-8 with cutting of the alternate trees at 7th year onwards for fuel is also recommended.
  - For productivity increment in scarcity area pearlmillet + pigeonpea (2:1) intercropping or ber (5x5 m) + mothbean (8 lines) is advocated.
- **Animal component:** Female buffalo/ sheep, goat

Nagpur, Wardha

- **Fodder/ green biomass:** *Leucaena leucocephala, Albizzia lebbeck, Dalbergia sissoo, Acacia indica, Acacia procera, Glyricidia*
- **Fruits:** Pomegranate, ber, mango, sapota, guava, tamarind
- **Medicinal and aromatic plants:** *Solanum viarum, Catharanthus roseus, Palmarosa, Vetiveria zizanoides Ocimum viride,* Safed Musli.
- **Vegetables:** Onion, chilli, brinjal, okra, amaranthus, bottlegourd, garlic.
- **Animal Component:** Male/ female cattle, female buffaloes, sheep, goat, poultry

Contingent crop planning

Bhandara, Chandrapur, Nagpur, Wardha

Regular monsoon

The monsoon starts by 24th meteorological week.

- **Light soils (20 to 30-35 cm depth)**
  - Graded bunding of lands
  - Growing of strips of erosion resistant crops Greengram (Kopergaon)/ blackgram (T-9) in the upper half of the plot and sorghum (CSH-9) in the lower half of the plot.
- **Medium deep soils (35-40 cm to 75 cm depth)**
  - Cotton (AKH 84635) with greengram (Kopergaon) as an intercrop in 1:1 row ratio.
  - Sorghum (CSH-13) with intercrop of greengram/ blackgram in 1:1 row ratio.
  - Groundnut intercropped with sunflower in the row ratio of 6:2 (groundnut: JL-24, Sunflower-Morden)
- **Deep soils (75 cm depth)**
  - Cotton - inter specific cultivation of hirsutum cotton (AKA-7 and AKH 4)
  - Hybrid cotton (AKH 4)
  - Sorghum (CSH-9/CSH-13) 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 to be sown instead of CSH-5/CSH-9.

- Area under greengram/ blackgram should be replaced by early pigeonpea varieties (ICPL 8863, ICPL 87119)
- Area under groundnut be reduced and replaced by sunflower hybrids

Regular monsoon followed by long gaps

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

Extended monsoon

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

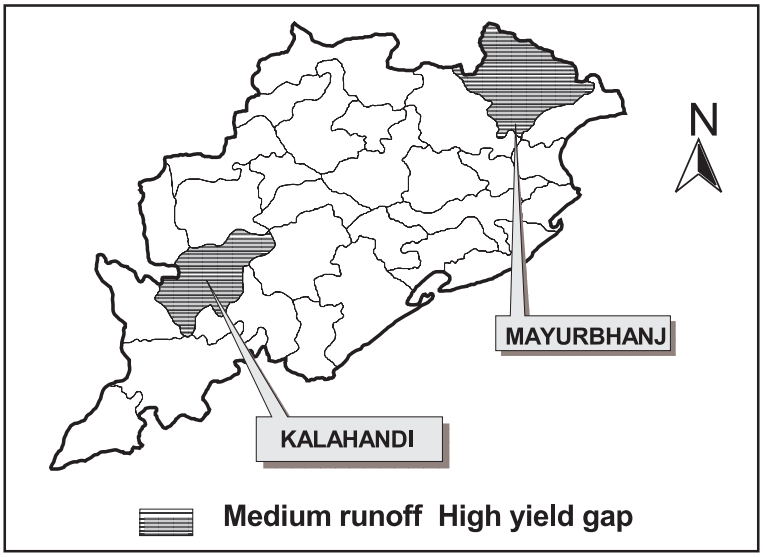
Jalna

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

- **Second fortnight of June:** All *Kharif* crops
- **First fortnight of July:**
  - Pearlmillet, setaria, groundnut, castor, pigeonpea, horsegram,
  - Intercropping of pearlmillet + 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, pearlmillet (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.

ORISSA

In Orissa there are two districts viz. Kalahandi and Mayurbhanj with medium runoff and high yield gap region.



District	Region
Kalahandi Mayurbhanj	Medium runoff and high yield gap

Agroecological setting

Kalahandi

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

Mayurbhanj

- **Climate:** Hot moist sub humid
- **Physiogrpahy:** Eastern Ghats
- **Soils:** Deep laomy red and lateritic soils (Ustalfs/ Ustolls -65%; Loamy Alfisols - 35%)
- **Annual rainfall:** 1361
- **Potential evapotranspiration:** 1641
- **Moisture availability period:** 180-210 days

Soil and water conservation

Kalahandi, Mayurbhanj

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

Crop management

Kalahandi, Mayurbhanj

- **Varieties:** Kiran, Laxmi, Sheetal, Padmini, Jawahar-23, LMH-62
- **Seed rate:** 25 kg/ha
- **Planting pattern:** 30 x 5 cm
- **Nutrient management** 30 kg N+20 kgP_2O_5 +15 kg K_2 O- all the nutrients should be applied as basal

Some other important practices:

- Blackgram/ greengram - linseed + chickpea/ mustard
- Sowing tme - first fortnight of October
- At the time of sowing appropriate soil moisture should be ascertained in the field provide protective irrigation
- Seed treatment with bavistin @ 1.5 g/kg of seed/ thiram 3 g/kg of seed/ Topsin - M @ 2.5 g/kg seed

Suitable cropping systems

Kalahandi, Mayurbhanj

- Linseed + chickpea (2:1/ 3:1)
- Safflower+ linseed - for uplands
- Sorghum-linseed - for uplands
- Cowpea-linseed - for uplands
- Rice-linseed - for midlands
- Alternate crops:
  - Mesta (AMV-1, AS-7)
  - Safflower (S-2-27, A-300)
  - Pearlmillet (BPC-39, IP-417)
  - Soybean (JS-1, Punjab-1)
  - Turmeric (Sudarshan)
  - Ginger (Nadia)

Farm implements/ tools

Kalahandi, Mayurbhanj

- **Mould board plough:** Suitable for primary tillage (1st and 2nd ploughing), requires a pair of bullock and covers 0.3 ha/day. Rs.252/-

- **Heavy soil plough:** Suitable for black cotton soil, requires a pair of bullock and covers 0.24 ha/day. Rs.324/-
- **Cast iron plough:** Suitable for ploughing and puddling in fields free from roots of trees and pebbles, requires a pair of bullock and covers 1.0 ha/day. Rs.266/-
- **Zig-zag puddler:** Puddling, requires a pair of bullock and covers 1.0 ha/day. Rs.1788/-
- **IADP Puddler:** Pulverizing light sandy loamy soil, puddling, suitable for heavy soils of western Orissa, requires a pair of bullock and covers 1.0 ha/day. Rs.1700/-
- **Pudller 99:** Pulverising all soils, puddling, requires a pair of bullock and covers 1.0 ha/day. Rs.1232/-
- **One row seed drill:** Seed sowing in rice, maize and groundnut, requires a pair of bullock and covers 0.3 ha/day. Rs.246/-
- **Two row multicrop seed drill:** Seed sowing in rice, wheat, groundnut and chickpea, requires a man and covers 0.5 ha/day. Rs.1164/-
- **Two row mustard seed drill:** Mustard sowing, requires a one man and covers 0.5 ha/day. Rs.827/-
- **Three row multicrop seed drill:** Seed sowing in rice, wheat, chickpea and groundnut, requires one man and covers 0.8 ha/day. Rs.1570/-
- **Rice transplanter** (Manual): Transplanting rice with proper spacing requires two men and covers 20 ha/day. Rs.4000/-
- **Pedal rice thresher:** Threshing of rice requires two men and covers 2.5 q/day. Rs.2754/-
- **Power rice thresher:** Threshing of rice requires an electric motor (1 HP) and covers 1.0-1.2 t/day. Rs.8778/- (with motor and starter).
- **Groundnut digger:** Digging groundnut requires a pair of bullock and covers 0.3 ha/day. Rs.548/-
- **Pedal groundnut thresher:** Separating groundnut pods from the plants requires two men and covers 0.22 t/day pods. Rs.2818/-
- **Groundnut decorticator:** Spreading seeds from groundnut pods require one man and covers 50 kg/hour. Rs.764/-
- **Maize Sheller:** Spreading seeds from maize cobs require one man and covers 100 kg/day. Rs.25/-

Alternating farming systems

Mayurbhanj

- **Alley cropping:** *Leucaena leucocephala* (4 m interval) + groundnut/ sesame/ cowpea (grain)
- **Silvipasture/ social forestry:** for denuded eroded, highly sloppy and shallowlands
- **Horticulture on uplands:** Mango, litchi, guava, lemon, custard apple, jack fruit
- **Agro-horti system:** Sweet potato + maize/ castor (spacing 80 x 25 cm), Yam (100 x 60 cm) + maize/ castor, Tapioca (100 x 100 cm) + maize / castor, Colocasia 980 x 25 cm) + maize / castor
- **Fodder/ green biomass:** *P. pinnata, Albizzia sps, Cassia siamea, Grevillea robusta, Dalbergia sissoo, Azadirachta indica*
- **Fruits:** Mango, Jack fruit, Guava, Lime
- **Medicinal and aromatic plants:** *Vetiveria zyzanoides, Cymbopogan flexuosus,* Palmarosa*, Solanum viarum, Cinnamon, Citronella java*
- **Vegetables:** Bottle gourd, Brinjal, Ridge gourd, Water melon, Long melon, Bitter gourd, Tomato
- **Animal component:** Female cattle, Male cattle, Goat

Kalahandi

- **Fodder/ green biomass:** *Dalbergia sissoo, Albizzia lebbek, Anogeissus latifolia, Sesbania, Stylo,* Marvel - 8 grass
- **Fruits:** Ber, Custard apple, Pomegranate, amla+ *kharif* spreading crops.
- **Medicinal/ Aromatic Plants:** *Catharanthus roseus, Palmarosa, Vetiveria zizanoides,* Rose, Geranium
- **Vegetables:** Onion, Tomato, Okra, Cowpea, Cluster bean, Drumstick
- **Non - arable wastelands:**
  - Tree farming (Sal, Teak)
  - Silvi-pastoral (Shisham/ Leucaena leucocephala/ Gambar + *Stylo*/*Cenchrus*/ mixure)
- **Arable wastelands:**
  - Agri-horticulture: Fruitcrops (mango/ citrus/ sapota/ pomogranate/ custard apple/ amla/ litchi/ jackfruit/ phalsa) + field crops (pulses/ oilseeds). Hybrid mango varieties viz. Pusa Amrapalli and Pusa Mallika are becoming increasingly popular in the zone.
  - Sweet potato + maize/ castor (spacing 80 x 25 cm)
  - Yam (100 x 60 cm) + maize/ castor
  - Tapioca (100 x 100 cm) + maize / castor
  - Colocassia (980 x 25 cm) + maize / castor
  - Alley cropping: *Leucaena leucocephala* (4 m interval) + groundnut/ sesame/ cowpea (grain)
  - *Leucaena* + turmeric/ ginger

Contingent crop planning

Kalahandi

Normal season

- **Rice:**
  - Very early group (less than 95 days): Heera, Rudra, ZHU 11-26, Vandana
  - Early group (95 days to 115 days): Pathara, Khandagiri, Udayagiri. Ghanteswari, Parijat
  - Early medium (115 days to 120 days): Sarathi, Bhoi
  - Medium duration (125 to 145 days): Lalat, IR-64, Konark, Gajapati, Surendra, Jajati, Swarna, MTU-1001, Padmini
  - Late duration : Utkalaprava, Gayatri, Savitri,Prachi, Ramachani, Mahanadi, Indrabati
- **Fingermillet:** Dibyasinha, Nilachala, Bhairabi, Subhra
- **Maize:** Navjot, Vijaya, DHM-103, Ganga-5
- **Greengram:** PDM-54, K- 851, Dhauli, TARM-2
- **Blackgram:** Pant U-30, T-9, Sarala
- **Pigeonpea:** UPAS-120, R-60, T-21, S-5
- **Cowpea:** SEB-2, SGL-1, Arka Kamal
- **Horsegram:** Urmi, Local
- **Groundnut:** Smruti (OG 52-1), JL-24, ICGS-11, AK 12-24
- **Castor:** GCH 4, Varuna etc., DCH-177, DCH-30
- **Rape seed mustard:** PT- 303, M-27, Parvati, Anuradha

- **Sesame:** Vinayak, Uma, Usha, Prachi
- **Niger:** Deomali (GA-10), IGP-76, Phulbani Local
- **Linseed:** Kiran, Laxmi-27, Pusa-3, Padmini
- **Sunflower**: Morden, hybrids
- **Cotton**: MCU-5, NHH-44, Somanath, Savita, Bunny
- **Ginger:** Vardhan, China, Nadia
- **Turmeric:** Sudarsan, Suguna, Subarna, Rajendra Horti-5.
- **Yam:** Hatikhoja, Srikirti, Srirupa

Aberrant weather

- **Upland**
- **Early season drought/ Delay in onset of monsoon:**
  - When upland rice is completely damaged, the crop may be cut down for supplying straw to the cattle. Non-rice crops viz. fingermillet (Subhra, Bhairabi, Dibyasingha and Godavari), Greengram (K 851, PDM-11 and PDM-54), blackgram (T-9, Sarala and Pant U-30), Cowpea (SEB-2, SGL-1, Arka Kamal), horsegram (Urmi), rice (RBL 6), Sesamum (Usha, Uma), Castor (GCH 4, Varuna etc., DCS-9), Niger (IGP-76 and Deomali) or Sunflower (Morden) should be taken. Drought tolerant varieties of crop(s)/ cropping system(s) should be taken up. The crop/ variety should be selected basing on available effective growing season.
- **Mid-season drought**
  - Weeding and hoeing should be done in all the crops except groundnut in flowering stage. Weeds in groundnut should be cut or uprooted not to interfere in pegging and pod formation. Hoeing creates soil mulch and decreases moisture loss from the soil. Uprooted weeds should be used as mulch between crop rows.
  - Foliar spraying of 2% urea in upland rice and fingermillet gives good results. For this, 200g of urea is mixed with 10 litre of water and sprayed on the foliage of the crop. Plant protection chemicals may be mixed with urea solution to minimize the cost of spraying. In a single spray 10 kg/ha of urea is applied through 500 l solution.
  - Excess plants in the crop row should be thinned to reduce moisture loss from the soil.
  - Use of tender twigs of *Leucaena, Glyricidia sepium, Cassia siamea* and *Mimosa invisa* and plants of sunhemp as mulch-cum-manure reduces evaporation loss from the soil.
  - Spraying of planofix 10 ppm at 45 days after sowing and 20 ppm at flowering in cotton to prevent fruit drop.
- **Late season drought**
  - Harvested rainwater should be recycled as life saving irrigation.

Medium and lowland

Direct sown rice

- Re-sowing of rice is needed if plant population is less than 50%. Line sowing of pre-germinated seeds of rice (125 days duration) should be done. Nursery for comparatively shorter duration rice varieties may be done.
- If plant population is more than 50% and '*beushaning*' is not possible, weeds are uprooted by manual means. Even distribution of plants *(Khelua)* should be taken up immediately by using local tools. Tillers with roots may be detached from hills with profuse tillering for planting in gappy areas. Urea solution (2%) may be sprayed to improve crop growth.

Transplanted rice

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

Mayurbhanj

Normal sowing period (15th to 30th June)

Monsoon sets in generally in the third week of June. Crops and varieties for normal onset of monsoon are

- Rice (Br.G. 23-19, Bandana, RAU- 4045 - 3)
- Fingermilet (A.404, PR.202, IE-723; direct seeding as well as nursery sowing of all the 3 varieties)
- Maize (Ganga Safed 2, Ganga 5, Suwan 1)
- Sorghum (CSH 5, CSH 6, other hybrids)
- Groundnut (AK.12-24, Birsa groundnut. 1, BG 1, BG 2, Birsa bold)
- Soybean (Birsa Soybean- 1, Bragg)
- Pigeonpea (BR 103, 65, Upas 120)
- Greengram (Sunaina)
- Blackgram z(T 9)
- Intercrop: Pigeonpea + rice, pigeonpea+maize, pigeonpea + groundnut, Pigeonpea + 2 rows fingermillet, pigeonpea + blackgram/ greengram, (two row) pigeonpea + 2 rows soybean.
- If the onset is delayed but is expected with in a week or 10 days of normal onset date - Dry seeding of all the rice and groundnut varieties mentioned above in mid June

Delayed sowing period (1 - 7 July)

- Groundnut seeding with AK- 12-24 can be extended upto first week of July. BG 1 and BG 2 should not go beyond June.
- Direct seeding of fingermillet (A-404, PR-202, IE-723)
- Pigeonpea (BR-183, BR.165, Upas 120, T.21)
- Blackgram (T- 9)
- Maize (Rajendra Makka, Diara) ridge planting
- Pigeonpea (BR-65)+ groundnut (AK-12-24) intercrop
- Greengram (Sunaina)

Very delayed sowing (2nd to 4th week of July)

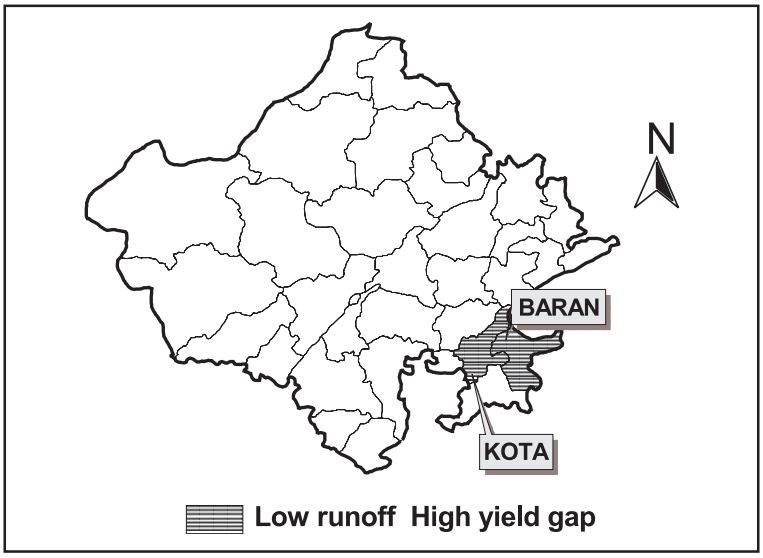
- Transplanting of fingermillet (all varieties) but spacing to be reduced from 20 x 15 to 20 x 10 cm
- Greengram (Sunaina)
- Blackgram (T-9)
- Sasame (Kanke white, Krishna)
- Sweet potato (Cross 4, Local)

Beyond July it is much too late for general crops. However, if seedlings are available transplanting of fingermillet could be resorted to in early August. Niger (N.5) and horsegram (BR. 10 Madhu) are the natural choice for August seeding.

- General precautions in case of delayed sowing
- Pre-monsoon tillage will pay dividends under such a situation in keeping weeds under control.
- Crops should be spaced a little closer to compensate for loss in growing period.
- Heavier dose of basal nitrogen and less number of splits should be followed specially in short duration crops.
- Under these conditions, since there is possibility of continuous rains proper care should be taken for the drainage of upland crops, which suffer from water logging at emergence state and some even at later stages.

RAJASTHAN

In Rajasthan there is two districts viz. Baran and Kota with low runoff and high yield gap.



District	Region
Baran	Low runoff and
Kota	high yield gap

Agroecological setting

Baran

- **Climate:** Hot moist semi arid
- **Physiography:** Western Malwa Plateau
- **Soils:** Deep clayey black soils, shallow black soils (Vertic soils - 100%)
- **Annual rainfall:** 850 mm
- **Potential evapotranspiration:** 1550 mm
- **Moisture availability period:** 120-150 days

Kota

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

Soil and water conservation

Baran, Kota

- 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

Baran, Kota

- **Varieties:** Triveni, Kiran, Padmini, Sheetal, T-397, Chambal, Jawahar-23, LCK 9313, LMH-62, Nagarkot
- **Seed rate:** 25 to 30 kg
- **Planting pattern:** 25 cm
- **Nutrient management** 40 kg N + 25 kg P_2O_5/ha
- **Some other important practices:**
  - Seed treatement with bavistin @ 1.5 g/kg of seed/ thiram 3 g/kg of seed / Topsin - M @ 2.5 g/kg seed
  - Blackgram/ greengram - linseed + chickpea/ mustard
  - Sowing - first fortnight of October
  - At the time of sowing appropriate soil moisture should be ascertained in the field provide protective irrigation

Farm implements/ tools

Baran, Kota

- Arjia Pora

Alternate farming systems

Baran, Kota

- **Fodder/ green biomass:** *Alianthus excelsa; Albizzia lebbek, Dalbergia sisso, Azadirachta indica, Prosopis cineraria*
- **Fruits:** Ber, Date palm, Jamun, Fig, Phalsa, Karonda
- **Medicinal / aromatic plants:** *Plantago orata, Cassia angustifolia*, safed musli, *Papaver somniferum*
- **Vegetables:** Clusterbean, Cowpea, Amaranthus, Round melon, Long melon
- **Animal component:** Female buffalo/ sheep, goat

Contingent planning

Baran, Kota

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 mustard or chickpea.

Normal onset followed by long gaps in rainfall

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

Delayed onset of monsoon

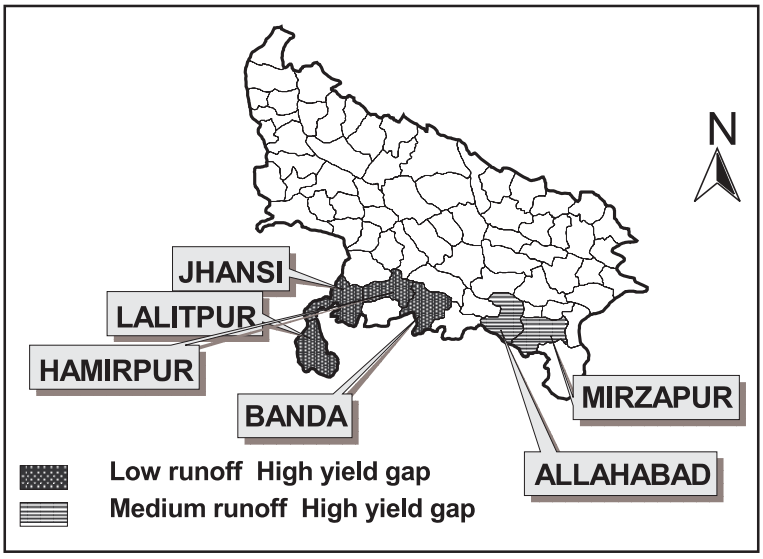
- Grow early maturing pulses (greengram, blackgram), oilseeds (sesame) and fodder crops (sorghum + cowpea). Intercropping of maize + blackgram / pigeonpea, groundnut + sesame is recommended

Early withdrawal of monsoon

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

UTTAR PRADESH

In Uttar Pradesh there are four districts viz. Banda, Hamirpur, Jhansi and Lalitpur with low runoff and high yield gap, two districts viz. Allahabad and Mirzapur with medium runoff and high yield gap.



District	Region
Banda Hamirpur Jhansi Lalitpur	Low runoff and high yield gap

Agroecological setting

Banda

- **Climate:** Hot moist semi arid
- **Physiography:** Bundelkhand Uplands
- **Soils:** Deep loamy and clayey mixed red and black soils (Inceptisols - 100%)
- **Annual rainfall:** 1005 mm
- **Potential evapotranspiration**: 1455 mm
- **Moisture availability period:** 120-150 days

Hamirpur

- **Climate:** Hot moist semi arid
- **Physiography:** Bundelkhand Uplands
- **Soils:** Deep loamy and clayey mixed red and black soils (Inceptisols - 100%)
- **Annual rainfall:** 998 mm

- **Potential evapotranspiration:** 1481 mm
- **Moisture availability period:** 120-150 days

Jhansi

- **Climate:** Hot moist semi arid
- **Physiography:** Bundelkhand Uplands
- **Soils:** Deep loamy and clayey mixed red and black soils (Inceptisols - 100%)
- **Annual rainfall:** 999 mm
- **Potential evapotranspiration:** 1516 mm
- **Moisture availability period:** 120-150 days

Lalitpur

- **Climate:** Hot moist semi arid
- **Physiography:** Bundelkhand 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

Banda, Jhansi, Lalitpur

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

Hamirpur

- 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

Crop management

Banda, Hamirpur, Jhansi, Lalitpur

- **Varieties:** T-397, Hira, RR 9, Swetha, Subhra, Sekhar, Padmini, Lakshmi-27, J-23, Kiran, Muktha, LCK 9313, Var-T-397, Neelam, Jwala-23, Garima, Swetha, Shubna, Kiran, Sheetal, LMH62, Gaurav, Shikha, LCK-9216, RL-993, K-2, Heera
- **Seed rate:** 25 to 30 kg/ha
- **Planting pattern:** 25 to 30 cm
- **Integrated nutrient management:** 40 kg N + 20 kg P_2O_5/ha

Some other important practices:

- Linseed + chickpea/ lentil/ barley
- Rice (early)- linseed
- Hybrid maize - linseed
- Cowpea (fodder) - linseed
- Blackgram/ greengram - linseed + chickpea/ mustard
- Sowing - first fortnight of October
- Seed treatement with Bavistin @ 1.5 g/kg of seed/ Thiram 3 g/kg of seed/ Topsin - M @ 2.5 g/kg seed
- At the time of sowing appropriate soil moisture should be ascertained in the field to provide protective irrigation

Suitable cropping system

Banda, Hamirpur, Jhansi, Lalitpur

- Linseed + chickpea (2:1/ 3:1) in mixed red and black soils
- Wheat + linseed in medium black soils
- Linseed + chickpea / lentil (3:1/1:3)

Farm implements / tools

Banda, Hamirpur, Jhansi, Lalitpur

- Seed cum ferti seed drill

Alternate farming systems

Banda, Hamirpur, Jhansi, Lalitpur

- **Fodder/green biomass:** *Leucaena, Melia azadirach, Dichrostachys cinerea, Albizzia amara, Albizzia lebbeck, 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, Goat, Poultry

District	Region
Allahabad Mirzapur	Medium runoff and high yield gap

Agroecological 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

Mirzapur

- **Climate:** Hot moist/dry sub humid
- **Physiography:** Ganga-Yamuna Doab
- **Soils:** Deep loamy and clayey soils (Inceptisols - 60%; Udupts/ Udalfs - 40%)
- **Annual rainfall:** 1112 mm
- **Potential evapotranspiration:** 1527 mm
- **Moisture availability period:** 150-180 days

Soil and water conservation

Allahabad

- 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
- Supplementing irrigation utilizing harvested water for negating adverse effect of late season drought by increasing production of rice by 25-30 per cent

Mirzapur

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

Crop management

Allahabad, Mirzapur

- **Varieties:** T-397, Hira, Neelam, Garima, Swetha, Subhra, Sekhar, Muktha, LCK 9313, Var-T-397, Jawahar-23, Shubha, Kiran, Sheetal, LMH62, Gaurav, Shikha, LCK-9216, RL-993, K-2
- **Seed rate:** 25 kg/ha
- **Planting pattern:** 25 to 30 cm
- **Nutrient management**
  - 40 kg N + 20 kg P_2O_5

- During *Kharif* place ½ N basal in seed furrows and remaining ½ top dress when surface is moist (30 to 40 days after seeding).

Some other important practices:

- Sow in lines only
- Place the seed in moist zone with the help of drills
- Linseed + chickpea/ lentil/ barley
- Rice (early)- linseed
- Hybrid maize - linseed
- Cowpea (fodder) - linseed
- Blackgram/ greengram - linseed + chickpea/ mustard
- Sowing - first fortnight of October
- Seed treatement with Bavistin @ 1.5 g/kg of seed/ Thiram 3 g/kg of seed / Topsin - M @ 2.5 g/kg seed
- At the time of sowing appropriate soil moisture should be ascertained in the field provide protective irrigation

Suitable cropping systems

- Linseed + chickpea (2:1/ 3:1)
- Tomato + linseed
- Linseed + chickpea/ Lentil (3: 1/ 1: 3)

Farm implements and Tools

Allahabad, Mirzapur

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

Alternate farming systems

Allahabad

- **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

Mirzapur

- **Agro horti system:** Gauva + maize
- **Fodder/green biomass:** *Leucaena leucocephala. Azadirachta indica, Albizzia lebbek, Bauhinia purpurea, A. procera, B.monosperma, A.amara, D.sissoo.*
- **Fruits:** Guava, amla, ber, mango, bael, jamun.

- **Medicinal and aromatic plants:** *Papaver somniferum, Cymbopogan flexuosus, P.rosalea, Palmarosa, Vettiveria zyzanoides.*
- **Vegetables:** Bottle gourd, brinjal, chillies, cluster bean, cowpea, round melon.
- **Animal component:** Female and male cattle, female buffaloes.

Contingent crop planning

Allahabad, Mirzapur

Normal season:

- ***Kharif***
  - Rice (NDR-97, NDR-118, Govind, Vandana)
  - Maize (Ganga safed 2, Kanchan, Jaunpuri)
  - Pearlmillet (BJ 104, Pusa 23, Pusa 322)
  - Blackgram (T.9, Pant U-19, Pant U -35)
  - Greengram (Jyoti, Jagriti, Janpriya, Pant moong-1, Narendra moong-1)
  - Sesame (T4, T12, Gujrat til-1)
  - Pigeonpea (Bahar, NA-1, T21)
- ***Rabi***
  - Lentil (Pant L-406, PantL-639, L 4076,K 75)
  - Wheat (HUW-533, K-8027, C-306)
  - Barley (DL3, Jyoti, K125)
  - Mustard (Varuna, Vardhan, Sanjukta, Kranti)
  - Linseed (Garima, Neelam)
  - Chickpea (Pusa 256, Awarodhi)

Aberrant weather

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 topdressing 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 & lowlands. 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 *pearlmillet* (BJ 60, BJ 104), blackgram (T9), greengram (Jagriti, Jyoti) should be taken up. Pulse base intercropping is also recommended. Yet another alternative could be to harvest a fodder of *sorghum*, *pearlmillet*, maize or mixture of either of cowpea, blackgram, greengram and one of the above fodder crops. These crops will be followed by winter crops like mustard, barley, lentil, linsed and chickpea.

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), sesame (T.13) may be done. *Sorghum*, maize, pearlmillet 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, pearlmillet (BJ 104) gave a fair performance
- Intercropping blackgram in inter rows 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, mustard or barley during *rabi*
- Late season drought coinciding with reproductive phase of upland rice is frequently experienced (3 out of 7years). If period of drought approaches 8-10 days, 25% yield could be compensated by one life saving irrigation (5 cm depth)

LINSEED CULTIVATION

Linseed (*Linum usitassimum* L.) belongs to the family Linaceae and the genus Linum that has 100 species. Apart from cultivated *L. usitassimum*, five wild species in India have been reported. They are *L. perenne*, *L. strictrum, L. mysorense*, *L. Angustifolium* and *L. grandiflorum*. It has been grown from ancient times for fibre (flax) and for its seed, which is rich in oil. Linseed is an annual herbaceous plant and grows to a height of 30 to 120 cm. Fibre types are tall growing and less branched than the seed types. It has a well-developed fibrous root system with many lateral roots. The stem is glabrous grayish green with leaves narrow and alternate. Fruit is a capsule, globular in shape mostly indehiscent. Seeds are compressed shinning yellow or light brown. The seed types with branching habit have less harvest index than the fibre types. In general harevest index varies from 0.19 to 0.31. The test weight is about 4.5 g/1,000 seeds. Number of capsules per unit area is the important yield component determining the yield and quality of linseed. Higher the plant density lesser is the capsule load per plant. Increased straw yield following increased density is stating the obvious.

Cultural practices

Season: Linseed is purely a cool season *rabi* crop. Temperate and cool climate conditions are best suited for growh. The minimum temperature regime is 10° C while themaximum is 38° C. Thus, the main season for sowing linseed is October to November depending upon the availability of soil moisture. Early sowing helps the crop to escape attack of powdery mildew, rust and linseed bud fly in different regions. The crop takes 120 to 140 days to mature depending on the cultivar. The oilseed crop needs about 25 to 30°C during germination and vegetative phase and 15 to 20°C during seed formation. An annual rainfall of 700 to 750 mm is optimum. Under dry climates irrigation is essential. A well-distributed rainfall of 450 to 500 mm can also suffice to grow good crop of linseed. The elevation of 400 to 500 mm from sea level is quite suitable. Drought and high temperature at early and seed filling stages are detrimental causing yield and quality reduction.

Cropping systems: Linseed for seed can be grown as a sole crop with adequate fertilization. It is is normally rotated with hybrid maize, sorghum, pearlmillet, groundnut and cowpea. On rainfed lands, intercropping of linseed particularly with chickpea, lentil, durum wheat, barley and safflower needs to be popularized on a priority basis. This will provide stability to total production from a unit land and higher monetary returns. When linseed is intercropped with chickpea, the incidence of wilt and pod-borer damage in chickpea is reduced and the inherent high risk of chickpea cultivation is minimized. The fertilizer needs ofchickpea and lentil is minimized when they are intercropped with linseed. As far as possible, mixed cropping should be discouraged and intercropping popularized. The intercropping systems are linseed + wheat, linseed + mustard, linseed + chickpea, linseed + cotton and linseed + *rabi* sorghum. The front line demonstrations by ICAR (India) had shown that linseed + chickpea has the highest monetary returns for farmers. Some of the efficient intercrop combinations for various states are indicated below:

State	Intercropping system
Hot Sub-humid (dry) Northen Plain (Uttar Pradesh other than Bundelkhand)	Linsded + Chickpea / Lentil (3:1 or1:3)
Hot Subhumid (dry) Central Highlands of Malwa and Bundelkhand (Uttar Pradesh Bundelkhand)	Linseed + Chickpea / Lentil (3:1 or 1:3) Liinseed + Wheat (1:3)
Hot sub-humid (dry) Central highlands including semi-arid Aravalli hills to Hot Moist/ Dry Subhumid Transistional Chatisgarh – Mahanadi basin (Madhya Pradesh, Chattisgarh)	Linseed + Chickpea (3:1), Linseed + Chickpea (3:1) Linseed + Mustard (5:1)
Deccan plateau hot semi-arid to arid Karnataka plateau (Maharashtra and Karnataka)	Linseed + Chickpea (3:1 or 1:3) Linseed + Safflower (Different row ratios)

Traditional relay *(piara/ utera)* cropping is one of the best practices for utilizing the residual moisture in rice fields where tillage is difficult. About 25% of the linseed area (~0.25 mha) is under *Utera.* In this practice,

linseed is broadcast in the standing rice fields when the crop is between flowering and dough stages (about 10 to 12 days before the rice harvest). It is allowed to complete its life cycle under the stress of moisture, with inadequate nutrients and plant protection measures, resulting in poor yields. The varieties recommended are R 552, Himalini and Janaki. Green manuring or FYM application to rice helps the *Utera* crop of linseed. The seed rate is 35 to 40 kg/ha and the fertilizer dosage is 60 kg N/ha. To improve linseed yield, "crack system" of sowing is suggested. The cracks of 5 cm deep are created in the rice field followed by 5 to 7 days in stagnated water, and then the linseed sowing is taken up in the rice field. Yield improvement of linseed is 100 per cent without any adverse effect on the paddy yield. Weed control is a major constraint in *Utera* cultivation. Plant parasitic weed *Cuscuta* is a major weed. Post-emergent spray of isoprotouron at 1.0 kg/ha (30 to 35 DAS of linseed) was effective in controlling wide spectrum of weeds.

Varieties: In India, the linseed varieties are of two types: peninsular types, which have deep root system and alluvial types, which are shallow-rooted and are characterized by profuse tillering. There are number of varieties available for cultrivation in different-croping systems, situations and for varied agro-climatic conditions in linseed. During the past 13 years, a considerable number of double purpose varieties were developed which are having good seed and fiber yielding potentials. There is an urgent need to replace the old varieties from the farmers' field with new improved high yielding and disease resistant varieties. Varieties differ in maturity, growth habit, and seed size and colour. A few popular varieties are K-2, T-397, No.55, NP (RR) 9, S-4, Jawahar-17, Jawahar-7 (R-7), M-10, Mayurbhanj, LC 185, Hira, Mukta, Neelum, B-67, B.S.44 etc. Details on some recent releases suitable for different regions are given below.

Variety	Area	Seed yield (kg/ha)	Duration (days)	Salient features
Shekhar (LCK)	Uttar Pradesh excluding Bundelkhand, Bihar, West Bengal and Assam for irrigated and rainfed areas	920	135-140	Resistant to powdery mildew, rust and wilt. Oil content is 43%
KL 120	Identified for Haryana, Punjab, HP and Jammu & Kashmir	850	149-158	Erect, purplish-blue flowers, yellow seeds, resistant to rust and free from wilt, and moderately resistant to *Alternaria* blight. Its oil content is 40%
SLS 27	Identified for Rajasthan, Bundelkhand (UP), MP, Maharashtra, Chhattisgarh, Orissa, AP and Karnataka	1500	118-125	Erect, white flowers, light brown seeds, moderately reistant to all diseases and pests. Oil content is 41.43%
RLU 6	Identified for MP, Rajasthan and Bundelkhand (UP)	1690 (860 kg/ha fibre)	136-145	Erect, white flowers, shinning borwn seeds, resistant to rust and bud-fly and moderately resistant to powdery mildew and *Alternaria* blight. Oil content is 40, 48%
RL 914	Rajasthan (State release)	1670	130-137	Erect, blue flowsers, borwn seeds, resistant to wilt and rust and moderately reistant to powdery mildew, *Alternaria* blight and linseed bud-fly. Oil content is 41%
NL 97 (State release)	Rainfed areas of Maharashtra	800-1,000	115-120	Moderately resistant topowdery mildew, wilt, linseed bud-fly. Oil content is 43%

Land preparation: It is often grown on marginal and sub-marginal rainfed soils. Two to three ploughings are done with subsequent 2 to 3 harrowings. Seedbed should be free from weeds and other debris. Linseed requires firm fine seedbed free from compaction and plough plan. There should be fewer larger clumps.

To conserve moisture, it is advisable to create soil mulch with the help of a hoe after each good shower. In most agroclimatic situations of India, October-November sowing is preferred. Delayed sowing reduces the yield and oil content. Its effect on oil content is pronounced.

Crop geometry: Line sowing is ideal. The optimum spacing is 20-30 cm between rows and 10 cm between plants. Drill sowing is preferred for uniform distribution of seed. The required seed rate for seed varieties is 20 to 30 kg/ha depending upon the seed size, which ensures a plant population of 0.4 to 0.5 m plants per ha. Depending upon the soil moisture, the seed should be placed 2 to 5 cm below the soil. Seeds are broadcasted under *Paira*/ *Utera* condition in standing paddy fields. For broadcast sowing the seed-rate is kept at 40 kg per ha. The field can be first ploughed when the moisture level is most appropriate, and a good plant stand can be ensured, if the seed is sown on the same or the next day at a very shallow depth. However, shallow sowing is always advantageous, if there is adequate moisture in the soil. Thin sowing gives a good number of tillers, but thick sowing is desirable for seed. The crop is grown either broadcast or is drilled in lines 20 to 30 cm apart: In the case of broadcasting, which includes utera sowing also, the seed-rate is kept at 40 kg per ha.

Fertilizer application: Linseed was nicknamed as the "robber crop" as it was supposed to exhaust the soil nutrients. However, it is not so. This crop is also known to change the *p*H of the rhizosphere andhence nutrient demands also vary. A ton of dual purpose (Giza-4) removes 55 kg N, 11.6 kg P, 34.8 kg K and 45 kg Ca and 9.8 kg Mg per ha. Linseed responds well to fertilizers. Fertilizer recommendation dose vary between agro-eco-regions. Fertrilizers should be applied at the time of sowing. Under rainfed conditions, the fertilizer dose of 30 kg of N and 15 kg of P per ha is given. The deep placement of fertilizer at sowing in the case of the rainfed crop gives better results. Nitrogen is applied in two splits, half the dose as basal and the other half at 40 to 50 days after sowing. The relay crop is fertilized at the rate of 10 kg of N per ha applied at the time of sowing. The rainfed crop generally requires no interculture. An application of 5 t FYM/ha can save 25% of inorganic fertilizer. NPK fertilizers are applied 5 to 10 cm away and below the seed in moist soil layers, especially under dryland cultivation. At optimal range N increased the oil content. Depending on the soil type, about 40 kg P_2O_5/ha is recommended for inseed. Diammonium phosphate is found superior to single superphosphate. Potassium is a quality element and improves oil and protein content of linseed. However, chlorides have a deleterious effect on soil quality. About 40 K_2O kg/ha is suggested. In K deficient soils, K dressing leads to increased height, technical length, trest weight and useful fiber per cent in stem. In the Indian subcontinent the general recommendations are 20 to 60 kg N, 10 to 30 kg P_2O_5 and 30 to 60 kg K_2O per ha. The NPK demand of linseed is more at bud formation to peak flowering. In S deficient soils, 30 S kg/ha is given through gypsum. Sulphur deficiency leads to fewer capsules. Linseed is considered moderately susceptible to B and Zn deficiency. Hence soil application of 1.0 to 1.5 kg B and 20 to 25 kg $ZnSO_4$ per ha to calcareous soils or recently limed soil has been suggested.

Fertilzier diagnostics in linseed have been worked out and the stem is taken as an index tissue. Seed yield of linseed was positively correlated with plant N content at vegetative and PK contents at budding and flowering stages. The sufficiency levels of NPK are associated with concentration ofN (20 to27 g/kg), P (5 to 10 g/kg) and S (20 g/kg).

Plant protection: Diseases and insect-pest are the major constraints that limit productivity. Alternaria blight is the the serious disease followed by powdery mildew; in Bundelkhand region of Uttar Pradesh, Madhya Pradesh, Orissa, Maharashtra, Rajasthan and Karnataka, wilt, powdery mildew and linsed bud fly are predominant; in the Chhattisgarh region of Madhya Pradesh and adjoining areas of Maharashtra and Orissa, *Cuscuta* (a phenerogamic plant parasitic weed) causes heavy losses. The losses in yield due diseases and pests in severe conditions are reported to be 40-100% by rust, 60% and above by powdery mildew, 27-60% by Alternaria blight, upto 80% by wilt and 97% by linseed bud fly. Bold and heavier seeds are selected and treated with Ceresan, Bavistin or Thiram or any organo-mercurial compound at 2 g/kg to keep the crop free from seed borne pathogens. The Indian Researchers have consistently found that cultivars resistant for fusarium wilt have capacity to accumulate more K, thereby offering resistance to the disease.

Termite, cutworm, wireworm, semilooper, leaf minor, bud fly and gram pod borer infest the crop and cause considerable damage. Aldrin or Chlordane 5% dust at the rate of 25-30 kg per ha is mixed within soil during the last ploughing before sowing to protect the seedlings against white ants and the early damage

from cutworms. Frequent ploughings are given to retain moisture and to check weeds in the field during the rainy season and a fine weed-free seedbed is prepared for sowing. BHC 10% or Aldrin or Chlordane 5% dust at the rate of 26-30 kg /ha is mixed within soil during the last ploughing before sowing to protect the seedlings against white ants and the early damage from cutworms.

Control of insects in linseed

Insect Pest	Control measures
Bud fly (Pre sowing)	Solarization of soil by ploughing; Avoid continuous cultivation of linseed in the same field
Termite (Land preparation)	Apply Methyl Parathion 2% dust @ 25-30 kg/ha in soil, when termites are regular and heavily damaging pest
All major pests (Sowing)	Sowing may be resorted 10-15 days earlier to minimize the bud fly infestation; Selection of suitable variety with tolerance to the key pest like Neela, Mukta, Garima, Shubhra, Laxmi-27, Kiran and Himalini
Cut worm and termite (Moderate infestation) (Seedling stage)	Dusting of the crop with Methyl Parathion 2% @ 25 kg/ha
Leaf miner, sap sucking pests and defoliators (Moderate infestation) (Vegetative stage)	Apply Monocrotophos 36 SL (0.04%) or Dimethoate 30 EC (0.03%)
Bud fly, leaf miner, Defoliator and sap sucking pests (6.0% ETL for bud fly and moderate to severe damage for other pests) (Flowering stage)	Use of light trap for bud fly; Use of attractant (1 kg Gur-Rabi in 75 lit. of water) for bud fly; Use of bamboo/wooden pegs as dead perches for predatory birds; Spray Phosphamidon 85 SL (0.03%) or Deltamethrin 2.8 EC (0.002%) or Endosulfan 35 EC (0.07%) alone or with Mancozeb (0.2%); Control leaf miner, defoliator and other sap sucking pests
Gram pod borer (Moderate to heavy damage) (Capsule formation stage)	Apply Monocrotophos 36 SL (0.04%) or Endosulfan 35 EC (0.07%)

Seed should be treated with Bavistin @ 1.5 g/kg seed orThiram @ 3 g/kg seed orTopsin-M @ 2.5 g/kg seed to protect the crop from seed-borne deseases and to some extent from soil borne diseases also. The imporatni diseases are wilt, alternaria blight and powdery mildew. Seed treatment with Thiram or Bavistin at 2 g/kg reduces the wilt mortality. Dithane M-45 at 0.25 percent of Calixine at 0.2 per cent reduces incidence of alternaria and blight. Spraying wettable sulphur can control powdery mildew. The important pest is the bud fly. Two fortnightly sprays of either phosphamidon (0.03%) or endosulphan 35 EC (0.07%) will check the pest. Linseed gall midge is the most widespread and serious pest of linseed. The growing of early varieties and mixed cropping are reported to reduce the incidence of the pest. Linseed rust and wilt are the two most serious diseases. The growing of resistant varieties is recommended to control these diseases.

Disease	Control Measures
Wilt *(Fusarium oxysporum f-lini)*	**Resistant/Tolerant varieties:** BAU 927, CI 2227, Coyat, EC 589Kiran, J-23, R-552, Jeevan, T-397, RL-993, Surabhi, Janki, LMH-62, LCK-9211, LCK-9216, LCK-9313, Himalini **Measures:** Deep summer ploughing; 2-3 years crop rotation is most effective prevention; use of resistant varieties, seed treatment with Thiram (3 g/kg seed) or Bavistin (1 g/kg seed) or Topsin-M (2.5 g/kg seed)
Alternaria blight (*Alternaria lini* and *Alternaria linicola*)	**Resistant /Tolerant varieties**: Ayogi, BAU 610 A, ES 44,LCK 9816, Jeevan, Nagarkot, RL-993, LCK-9216, LCk-9211, LCK-9313 **Measures:** Seed treatment with Iprodion (1 g/kg seed) and Topsin M (2.5 g/kg seed); Need based spray (2-3) of Prochloraz or Mancozeb 0.25% or Iprodion (Rovral) 0.2%.

Rust (*Melampsora lini*)	**Resistant /Tolerant varieties**: KL 178, LCK 9826, RL (U) 6, DPL 14, Nagarkot, Surabhi LC-54, LC-185, J-23, Himalini, R-552, Kiran, Surabhi, Janki, LMH-62, LCK-9211, Nagarkot, LCK-9313, LCK-9216, RL-993, Jeevan, Garima, Sweta, T-397, Gaurav, **Measures:** Early sowing; Destroy plant debris and weeds to reduce the primary sources of infection; use of clean seed, seed treatment with Oxycarboxin, Spray of calixin (0.05%) or Benomyl (0.1%) or Calixin + Dithane M-45 (0.025%) at 15 days interval control the disease
Powdery mildew (*Oidium lini*)	**Resistant /Tolerant varieties:** Ayogi, KL 178, KL 209, LCK 89512, NDL 97-5 LC-54, Himalini, J-23, R-552, Kiran, Surabhi, Nagarkot, Janki, LMH-62, LCK-9211, LCK-9313, LCK-9216, RL-993, Jeevan **Measures:** Use of resistant/tolerant varieties, Early sowing, 2-3 sprays of Calixin (0.05%) or Karathane (0.1%) or Wettable Sulphur (0.3%) reduces the disease.

IPM for common Pest Bud fly (AICRPL 2000-01):

- Garima, Shubra, Sweta, Laxmi-27, Sekhar, Sheela
- Linseed+chickpea (3:1)
- Linseed + mustard (6:1)
- Need based spray of Endosulfan 35 EC (1-25 kg/ha), Monocrotophos 36 (750 ml/ha)
- Linseed + chickpea (3:1) at recommended agronomic inputs +dead perches @ 40-50 pegs/ ha and need based application of systemic insecticides (Imidacloropid 2005 L, 100 ml/ha or Dimethoate 30 EC 0.03% for bud fly.
- Spray endosulfan 35 EC(0.07 %) or delta methylene 2.8 EC (0.002 %)
- Use of light trap
- Use of bamboo/ wooden pegs as dead perches for predatory birds

It is necessary to keep the crop free from weeds for the first 35 days after sowing. Isoproturon 75 WP @ 1.0 kg/ha either with or without 2, 4-D (sodium salt) @ 0.50 kg/ha as post emergence at 35 days after sowing can control weeds effectively. Linseed is a poor competitor over weeds and the first 25 to 30 days are critical. The weeds associated with linseed are *Chenopodium album, Anagallis arvensis, Brassica sinensis, Setaria viridis, Convolvulus arvensis, Carthamum oxycantha, Melilotus* sp and *Medicago sp*. One or two hand weedings normally keep the weeds in check. The herbicides such as Barban and Propham at 0.25 to 0.4 kg/ha have been tested as pre-emergent spray. A preplant application of diuron/linuron at 1.0 to 1.5 kg a.i./ha is quite effective. In the Chhatisgarh region of Madhya Pradesh and adjoining areas of Maharashtra and Orissa, *Cuscuta* (a phenerogamic plant parasitic weed) causes heavy losses.

Parasite	Control measures
Dodder/cuscuta (*Cuscuta hulina*)	Mechanical removing of parasitic vine from fields and parasitic seeds from seed lot; Preventing the movement of grazing animals from infested fields; Restricting the flow of irrigation water from infested area.

Supplmental Irrigation: Linsed is raised normally as a rainfed crop. If the winter rains fail, one or two irrigations depending on availability at terminal drought period augment the production of seed. The consumptive use of water for linseed ranges from 10 to 15 cm, with the peak need at flowering and grain development stage. The floweringstage is critical in respect of water supply. Yield can be doubled if two irrigations are given, the first at about 35 days after sowing and the second at about 65 days after sowing. However, three irrigations (at about 35, 55 and 75 days after sowing) have proved very effective in increasing the yield.

Harvesting and Storage: The crop should be harvested when the leaves are dry, the capsules have turned brown and the seeds have become shiny. The linseed crop starts maturing by the mid of February, depending on winter spread and sowing time. Plants turn golden yellow when the crop is mature and ready for harvesting. Harvesting is done when the crop is dead ripe with a sickle or by uprooting the plants. When

the fibre is also desired along with seed, the harvesting of the crop is done at the stage of capsule maturity even when the crop is slight green. Linseed is threshed after it is completely dry. The crop is threshed either by beating it with a stick or by trampling it under the feet of the bullocks. Hand beating is better to get fibre, along with seed. Seed is separated from the chaff by winnowing and is stored in a dry place. Initial moisture, fatty acid content oflinseed and storage conditions are the most important factor which affect the stability of linseed in storage. A relative humidity of 70% with 8% moisture content in theseed is the best conditions for its storage.

Some tips to maximize yields: The average yield of a pure crop varies from 210 to 450 kg per ha of seed under rainfed cultivation. The crop in northern India generally gives higher yield than in central and peninsular India. The irrigated crop may yield 1,200 to 1,500 kg per ha. The percentage of oil in the seeds varies from 37 to 43, but the commercial extraction in expellers of rotaries gives about 33 per cent from small seeds and 34 to 36 per cent from hold seeds. Crushed in village ghanis, the seeds yield only 25 to 30 per cent of oil. The linseed crop starts, maturing by the middle of February, depending on winter spread and sowing time. Agronomic practices for linseed in different crop growing situations follow:

State	Optimum time sowing	Spacing (cm)	Seed rate (kg/ha)	Fertilizers N:P:K (kg/ha)
Bihar	Mid October	25	30	40:20
Haryana	Second Fortnight of October to first week of November	25	20-25	60-80:30
Karnataka	Up to first week of October	25	25-30	40:20
Madhya Pradesh	First fortnight of October	25	25-30	30:15
Maharashtra	First fortnight of October	25	30	40:20
Orissa	First fortnight of October	25	25-30	30:15
Punjab	Mid October to Mid November	25	25-30	60-80:30
Rajasthan	Mid October	25	25-30	40:20
Uttar Pradesh	Mid October	25	25-30	40:20
Bundelkhand of UP	First fortnight of October	25-30	25-30	40:20

Clean, fine, weed-free seedbed should be prepared by ploughing during the rainy season.

- 10% B.E.C. or 5% Aldrin or Chlordane at the rate of 25 to 30 kg/ha be mixed with the soil at the last ploughing before sowing.
- Early sowing escapes the attack of many diseases and pests. Under utera, sowing is done at the dough stage of rice.
- Cultivate the recommended varieties.
- Integrated Pest management (AICRIL, 2000-01):
  - Need based plant protection measures, particularly against rust, powdery mildew and wilt diseases
  - Early weed
  - Control.
  - Keep the crop weed free for 1st 35 days after sowing
  - Isoproturon – 75 WP at 1 kg/ha either with/ without 2, 4-D (Sodium salt) @ 0.5 kg/ha as post emergence at 35 days after emerging
  - In, Madhya Pradesh, linseed+ safflower (4:2) intercropping system and its fertilization @100% recommended dose of fertilizer to both the crop (on area basis) may be remunerative.
  - In Jharkhand, linseed+chickpea (4:2) @100% recommended dose of fertilizer to both the crops on area basis.
  - In Maharashtra, linseed+chickpea (4:2) and linseed+ safflower (4:2) are better.

- For *Utera* crop cultivation:
  - Popular varieties Jawahar-7 and R-552 should be grown in Madhya Pradesh and adjoining areas of Orissa and Surabhi, LC-185
  - The application of 30 N+15 P for the rainfed crop and 10 N kg per ha for the *utera (relay)* sowing is recommended. A dose of 10 to 20 kg N/ha should be applied 2 or 3 days before linseed is sown.
  - Optimum seed rate of 30 to 40 kg per ha and a closer row spacing between 20 and 30 cm and 40 kg seed per ha for *utera (relay)* sowing.
  - Heavy-textured soils with good water-retention capacity should be preferred
  - Sufficient farmyard manure (FYM) or green manure should be applied along with phosphatic fertilizers to rice
  - Cuscuta infestation, particularly in the Chhattisgarh region of Madhya Pradesh, causes heavy losses. To ensure clean cultivation, *cuscuta* seeds should be separated and discarded from the seed lot before sowing linseed
  - Sowing linseed when rice is at the dough stage has proved tobe the best. However, sowing may be done 10 to 12 days before rice is harvested, butshould be completed by Octobver.
  - The weather should be clear at the time of sowing. Rains affect the plant stand adversely
  - Manual weeding should be done once ortwice
  - Crack system ofsowing is a new method which can be followed in areas when sufficient water isavailable.
  - Under *utera* system, linseed should be popularized as a mixed crop with greengram, blackgram and lathyrus, which are under cultivation in the system.

Prioritised cultural options for different districtsin various states follow based on yielg gap and average annual runoff.

State	District	Prioritised Options	Average yield (kg/ha)	Expected yield (kg/ha)
Chattisgarh	Durg, Rajnandgaon	Better water management techniques with crop management technologies to reduce yield gap	205 205	245 to255 245 to 255
Karnataka	Bijapur	Appropriate crop management technologies to bridge yield gap	300	360 to375
Madhya Pradesh	Damoh, Panna, Rewa, Satna, Sidhi	Adoption of improved varieties, crop management technologies, supplemental irrigation if possible. Permanent soil conservation measures	250	300 to 315
	Mandla, Shahdol Chattarpur Balaghat, Hoshangabad, Jabalpur, Raisen, Sagar, Seoni Guna, Sehore, Shivpuri	Better water management techniques with crop management technologies to reduce yield gap	205 375 350 520	245 to 255 450 to 465 420 to 440 620 to 650
Maharastra	Aurangabad Beed, Latur, Osmanabad, Parbhani	Appropriate crop management technologies to bridge yield gap	130 195	155 to 165 230 to 245
	Nagpur, Wardha	Adoption of improved varieties, crop management technologies, supplemental irrigation if possible. Permanent soil conservation measures	250	300 to 315

State	District	Prioritised Options	Average yield (kg/ha)	Expected yield (kg/ha)
Maharastra	Bhandara, Chandrapur, Jalna	Better water management techniques with crop management technologies to reduce yield gap	205	245 to 255
Orissa	Kalahandi, Mayurbhanj	Better water management techniques with crop management technologies to reduce yield gap	350 520	420 to 440 620 to 650
Rajasthan	Kota	Appropriate crop management technologies to bridge yield gap	195	235 to 245
Uttar Pradesh	Lalitpur	Appropriate crop management technologies to bridge yield gap	455	545 to 570
	Banda, Hamirpur, Jhansi, Mirzapur	Better water management techniques with crop management technologies to reduce yield gap	375 520	450 to 465 620 to 650

Though, in experimental fields, on average basis, linseed yields 20 q/ha seed and 1.2 t/ha fibre, the national average yield is very low. There is a vast gap between the achievable yield and the national average as has been demonstrated through Frontline Demonstrations on farmers' field. Hence, considering linseed as economically competent crop, every effort should be made to use supplemental irrigation, fertilizers, plant protection measures, etc., to grow bumper linseed crop in turn to have maximum net returns from unit area, time and input.

- Grow recommended resistant variety
- Use quality seed of the recommended varieties
- Treat the seed with fungicide, bactericide, etc., as recommended
- At the time of sowing appropriate soil moisture should be ascertained in the field
- Take up sowing at appropriate time
- Keep the field weed free at least up to 40 days after sowing
- Apply recommended doses of fertilizers at appropriate time
- Adopt need based recommended plant protection measures against insect pests and diseases
- Provide protective irrigation
- Harvest the crop at physiological maturity

Linseed backed Agri-entrepreneurships vis-*a vis* Rural Livelihoods

Linseed area decreased from 1.424 m ha in 1986 to 0.754 m ha in 2001 decreasing production from 0.376 m t to 0.244 m t even though the productivity increased from 264 to 324 kg/ha. A parody is that doubled import of crude linseed oil from 94 m t in 1994-95 to 176 m t in 1997-98, in a short period of three years. This reveals lack of competitiveness in the local seed production due to externalities desiring other avenues. Over time the cost of production increased in oilseeds. The market product price of main product of linseed is also on increase but the oil price was fluctuating between Rs. 2693 to Rs.2777 per ton. Consequently, the farmers are put to indecision whether the area increase and technology adoption should go hand in hand. A most imperative decision would be to follow low risk traditional strategy. By revitalizing the traditional area under linseed increasing livelihoods is possible. It is seen from 177 Front Line Demonstrations on 78 ha across India (2001 – 02) conducted by KVKs that the yields can jump from 0.5 t/ha to 0.89 t/ha, showing an increase by 78 percent with the available varieties and package of practices (DARE Annual Report, Ministry of Agriculture).

In this context, the conversion of linseed to bio-diesel acquires importance. However, this technology should be limited to contiguous large regionalized zones to acquire marketable quantities. Among the 51 rainfed Districts identified for linseed area, six districts contribute (Raipur, Gulbarga, Durg, Kota, Beed and Bilaspur) 25% to cumulative production while ten more districts (Hoshangabad, Rewa, Vidhisha, Bhandara, Guna, Parbhani, Dhar, Satna, Sawai Madhopur and Balaghat) to bring the cumulative production to further 50% linseed grain (about 0.6 mt).

In 2001, the linseed oil production was 0.1 mt. In this it is expected farmers consume 20 percent oil and remaining 80 percent oil is used in inks, paints, etc. With the proven package of practices from FLDs, the 0.1 mt of production of oil can be increased to 0.18 mt. This additional 0.08 mt can be converted to bio-diesel with 80 percent conversion rate. Thus, there will be an availability of 0.064 mt of bio-diesel against an estimated requirement of 1.99 mt. with 5 per cent blending rate to diesel. This is possible if the technology is adopted in 51 districts in the rainfed zone. This can be realized by concentrating in the 16 districts mentioned above in the states of Maharashtra, Madhya Pradesh, Chhattisgarh and Rajasthan. It is expected to create an employment of 2 to 4 man days for ton of linseed grain for conversion to bio-diesel. Thus both agricultural related and other agricultural dependent enterprises can be developed in the target areas.

With this kind of interventions, the lost area under linseed at the peak during Technology Mission on Oilseeds can be regained in the traditional proven linseed land use based production zone creating more labor requirement. This linking of industry to agriculture can create and sustain rural based agri- entrepreneurships that happened in soybean system in Central India.

Some Popular and Botanical Names of Crops

Arhar (Redgram)	*Cajanus cajan* (L.) Millsp.
Bajra (Pearlmillet)	*Pennisetum americanum* (L.) Leeke
Barley	*Hordeum vulgare* L.
Bengalgarm (Gram; Chickpea)	*Cicer arietinum* L.
Blackgram (Urd)	*Vigna mungs* (L.) Hepper
Blue panic	*Panicum antidotale*
Castor	*Ricinus communis* L.
Chilli	*Capsicum frustescens* L.
Clusterbean (Guar)	*Cyamopsis tetragonolobus* (L.) Taub
Coriander	*Coriandrum sativum* L.
Cowpea	*Vigna unguiculata* (L.) Walp
Fingermillet (Ragi)	*Eleusine coracana* (L.) Gaertn
Foxtail millet (Setaria, Italian millet)	*Setaria italica Beauv*
Gingelly (Sesamum, Sesame, Til)	*Sesamum indicum* L. *Sesamum orientale* L.
Gram (Bengalgram)	*Cicer arietinum* L.
Greengram (Moong)	*Vigna radiata* (L.) Wilczek
Groundnut (Peanut)	*Arachis hopogaea* L.
Guar (Cluster bean)	*Cyamopsis tetragonolobus (L.) Tabu*
Horsegram	*Macrotyloma uniflorum* (Lam.) Verdc
Hybrid Napier	*(Pennisetum purpureum x P. typhoides)* F1
Indian bean (Lablab)	*Lablab purpureus* (L) Sweet
Indian rape (Toria)	*Brassica campestris* L.
Indian squash melon (Tinda)	*Citrulus fistulosus*
Italian millet (Foxtail millet, Setaria)	*Setaria italica* Beauv
Jowar (Sorghum)	*Sorghum bicolor* (L.) Moench
Jute	*Corchorus capsularis L.*
Kabuli gram	*Cicer arietinum* L.
Lentil (Masoor)	*Lens culinaris Medic*
Maize	*Zea mays* L.
Mesta (Rozella)	*Hibiscus Sabdariffa* L.
Moth (dew gram)	*Vigna aconitifolia (Jacq.) Marechal*
Mustard (Raya)	*Brassica juncea* Coss.

Napier Grass	*Pennisetum purpureum*
Niger	*Guizotia abyssinica* (L.f.) Cass
Rice (Paddy)	*Oryza sativa* L.
Peanut (Groundnut)	*Arachis hypogaea* L.
Pearlmillet (Bajra)	*Pennisetum americanum* (L.) Leeke
Peas	*Pisum Sativum* L.
Pigeonpea (Arhar, Redgram, Tur)	*Cajanus cajan* (L.) Millsp.
Potato	*Solanum tuberosum* L.
Proso millet	*Panicum miliaceum* L.
Ragi	*Eleusine coracane* (L.) Gaertn
Rajgira (Amaramthus)	*Amaramthus viridae L.*
Rapeseed (Sarson)	*Brasica campestris* L. var. Sarson Prain
Raya (Mustard)	*Brassica juncea* (L.) Czern. & Coss
Redgram (Pigeonpea, Arhar, Tur)	*Cajanus cajan* (L.) Millsp
Rice (Paddy)	*Oryza sativa* L.
Rozella (Mesta)	*Hibiscus sabdariffa* L.
Safflower	*Carthamus tinctorius* L.
Sarson (Rapeseed)	*Brassica campestris L. var. Sarson Prain*
Sesame (Sesamum, Gingelly, Til)	*Sesamum indicum* L.
Setaria (Foxtail millet, Italian millet)	*Setaria italica Beauv*
Siratro	*Macroptilium purpureum* L.
Sorghum	*Sorghum bicolor* (L.) Moench
Soyabean or Soybean	*Glycine max (L.) Merr*
Sunflower	*Helianthus annuus* L.
Sweet Potato	*Ipomea batatas (L.) Lam*
Taramira (Rocket salad)	*Eruca sativa* Mill
Til (Gingelly, Sesamum, Sesame)	*Sesamum indicum* L. *Sesamum orientale* L.
Tinda (Indian Squash Melon)	*Citrulus fistulosus*
Tobacco	*Nicotiana tabacum* L.
Toria (Indian rape)	*Brassica campestris var toria Duthie & Fuller*
Tur (Redgram, Pigeonpea, Arhar)	*Cajanus cajan* (L.) Millsp.
Triticale	*Triticale officinale*
Urd (Blackgram)	*Vigna mungo* (L.) Hepper

Some Generic & Brand Names of Insecticides

I. Insecticides

Adicarb: Temic 10G (Rhone Poulenc)

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

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

Carbosulphan 25% DS: Marshal (Rallis)

Chlorpyriphos 20EC, 10G, 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 Incesticides), 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 10EC: Ralothrin (Rallis), Ankush (BASF), Simper (ICI-Zeneca), Hi-Power (Sulphur Mills), Spec Cyperin (Southern Pesticides), Hycyper (Hyderbad Chemicals), Cyper Top (Thakar Chemicals), Lacer (Searle India), Agro-Cyper (Gujarat Agro), Jawa (Dupont), Cypercin (IOCL), Super Killer (Dhanuka), Cypermil (Montari), Polytrin (Novartis), Cyproid (AIMCO), Challanger (Tripical 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), Cypercin (IOCL), Challanger (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 20EC, 10% Gr: Basudin (Novartis), Tik-20 (Rallis)

Dichlorovos 76EC: 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 35EC & 4% D, 2% D: Thiodan (Agro Evo), Endocel (Excel), Endosul (Sulphur Mills), Endostar (Shaw Wallance), 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 Chemmicals)

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

Fipronil 0.3% Gr, 5% SC: Regent (Rhoune – Poulnec), Tempo (Agr Evo)

Formothion 25%: Anthio (Novartis)

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

Malathion 50 EC: Dhanuka Malathion (Dhanuka), Cythion (Cyanamid Agro), Sulmathion (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), Luphos (Lupin), Kadett (Pesticides India), Agromonark (Gujarat Agro), Moncar (Bhaskar Agro), Azodrin (Cyanamid Inida), Hilcron (Hindustan Insecticides), Macrophos (Tropical Agro), Croton (Searle India), Balwan (Rallis), Monophos (Parry Chemicals), Monocron (NFCL), Corophos (Coromandel Indag), Bilphos (Bayer), Monosect (Arg Evo)

Methyl-parathion 50EC: 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 25EC: Metasystox (Bayer), Hexasystox (Parry Chemicals), Dhanusystox (Dhanuka), Mode (Agr Evo)

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

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

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

Quinalphos **25EC:** Ekalux AF (Novartis), Quinaltaf (Rallis), Flash (Indofil), Quinal (Sulphur Mills), Suquin (Sudershan Chemicals), Quinguard (Gharda), Starlux (Shaw Wallace), Knock (Southern Pesticides), Hyquin (Hyderabad Chemicals), Ekatop (Thakar Chemicals), Smash (Searle India), Chemlux (New Chemi), Shakti (E.I.D. Parry), Dhanulux (Dhanuka), Quinatox (AIMCO), Kinalux (United Phosphorous), Vazra (Lupin), Agro-quin (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 (Rhoune-Poulnec)

II. Fungicides

Aureofungin 46.15% SP: Aureofungin Sol (Hindustan Antibiotics)

Captafol 80%: **Foltaf (Rallis)**

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

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

Edifenphos 50 EC: Hinosan (Bayer)

Hexconazole 5% EC: Contaf (Rallis)

Mancozeb 75%: Dithane M-45 (Bayer), Uthane M-45 (United Phosphorous), Luzen (Lupin), Dhauka M-45 (Dhanuka), Hilthane (Hindustan Insecticides), Shield (Pesticides India), Spic Mancozeb (Spic), Zeb (NFCL), Manzate (Dapal), Zebthane (Rallis), Luzim (Lupin), Abic M45 (novartis), Aimcozeb (AIMCO), Agromanco (Gujarat Agro), Indofil M-45 (Indofil), Sparsh (Wockhardt), Saviour (De'Nocil)

Propiconazole: Radar (Rallis), Tilt (Navartis)

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

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

Tridemorph 80% EC: Calixin (BASF)

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

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

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

III. Herbicides/ weedicides

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

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

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

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

Butachlor 50 EC, 5 GR.: Machete (Monsanto), Teer (Rallis), 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 8G, 25%, 24%: Tok-E-25 (Indofil)

Oxadiazon 25% EC: Ronstar (Rhone-Poulnec)

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).

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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	-	emulsfiable concentrate
ETL	-	economic threshold level
FYM	-	farm yard manure
g	-	grams
G	-	granules
gsm	-	grams per square meter
ha	-	hectare
HNVP	-	*Heliothis* Nuclear Virus Production
K_2O	-	pottasium
kg	-	kilogram
LE	-	larval equivalent
l	-	litre
ml	-	millilitre
m	-	metre
N	-	nitrogen
O.C	-	organic carbon
P_2O_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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4. Research Publications and Recommendations in Dryland Agriculture-Annotated Bibliography (1971-2002)
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