a compendium of AICRPDA, CRIDA, AICPMIP, NRCS, AICRPM, SAUs, and Agro-Industries

Districtwise Promising Technologies for Rainfed Cereals based Production Systems in India

Editors

G Ravindra Chary
GR Maruthi Sankar
G Subba Reddy
YS Ramakrishna
AK Singh
AK Gogoi
KV Rao

All India Coordinated Research Project for Dryland Agriculture
Central Research Institute for Dryland Agriculture
Hyderabad - 500 059

2008

Contributors

All India Coordinated Research Project for Dryland Agriculture (AICRPDA), Hyderabad
G Ravindra Chary
G Subba Reddy
GR Maruthi Sankar

Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad
YS Ramakrishna
KV Rao

Indian Council of Agricultural Research (ICAR), New Delhi
AK Singh
AK Gogoi

All India Coordinated Pearl Millet Improvement Project
IS Khairwal

National Research Centre for Sorgum
N Seetharama

All India Coordinated Research Project on Millets
KT Krishne Gouda

Agro Industries
• Implements • Seeds
• Fertilizers • Pesticides

Main Centres
AM Patel, SK Nagar
B Behera, Phulbani
Bhagwan Singh, Faizabad
DN Singh, Ranchi
DP Dubey, Rewa
DR Padmani, Rajkot
JR Kadam, Solapur
K Veerabadra Rao, Anantapur
MA Shankar, Bangalore
MB Guled, Bijapur
MB Nagdeve, Akola
MG Umate, Parbhani
MP Jain, Indore
PK Mishra, Bellary
PM Jain, Arjia
RP Mor, Hisar
SB Tripathi, Jhansi
SC Sharma, Ballowal Saunkhri
SK Patil, Jagdalpur
SPS Chauhan, Agra
SR Singh, Varanasi
V Subramanian, Kovilpatti

Operational Research Projects (ORPs)
DH Ranade, Indore
H Mariraju, Bangalore
LK Midha, Hisar
MS Yadav, Ranchi
SK Sharma, Arjia
SP Surve, Solapur
Sukhwinder Singh, Ballowal Saunkhri
Y Padmalatha, Ananthapur

State Department(s) of Agriculture
• Andhra Pradesh • Chhatisgarh • Gujarat • Haryana
• Karnataka • Madhya Pradesh • Maharashtra • Orissa
• Rajasthan • Tamil Nadu • Uttar Pradesh

Secretarial Assistance by
G Varalakshmi

Technical Assistance by
A. Girija, RVVSGK Raju, L Sree Ramulu

GIS Support by
I Ram Mohan

Supported by
S Devika and I Usha Rani

Other Assistance
N Manikya Rao, V Amarender

The opinions in this publication are those of the locations. The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the AICRPDA, CRIDA or ICAR. Where trade names are used this does not constitute endorsement of or discrimination against at product.

Printed at : Vamsi Art Printers Pvt. Ltd., Hyderabad, Ph : 040-23311858

Contents

INTRODUCTION

Rainfed Agro-eco system occupies the largest cultivated area in the country and produces most of rainfed cereals (Maize, Sorghum, Pearlmillet, Fingermillet and other minor millets), pulses and oilseeds. These crops provide staple food for millions of poor people in arid and semi-arid regions. These crops are highly adopted to drought conditions and are also the major source of fodder for live stock

Among rainfed cereals, sorghum is the third major food grain of the country grown in 11-12 m ha**.** There has been a steady decline in area under *kharif* sorghum over the last three decades, despite substantial improvement in productivity. At all India level, significant replacement of *kharif* sorghum area took place with competing crops, while *rabi* sorghum is staple food crop for millions of people in Maharastra and Karnataka. The area under sorghum in *rabi* remained more or less constant but the productivity has not improved significantly since it is grown with residual moisture. Pearlmillet is grown in 9.9 m ha in rainfed environment in 340 districts of the country. The area under this crop is stagnant in Madhya Pradesh, Maharastra, Gujarat, Tamilnadu and Karnataka. But the productivity is increasing in all pearlmillet predominant districts except in states of Gujarat, Maharastra and Uttar Pradesh. Fingermillet is predominantly grown in states of Karnataka, Maharastra, Andhra Pradesh and Orissa. The area under this crop is decreasing in the states of Karnataka and Orissa while it is stable in Maharastra and Andhra Pradesh. The productivity is stable in Orissa and Maharastra while it declined in Karnataka and increased in the state of Andhra Pradesh. Among cereals, maize is grown in 5.6 m ha out of which 3.95 m ha (86%) is rainfed. The area under this crop is stable in Punjab, while it showed an increasing trend in the states of Rajasthan and Andhra Pradesh. The productivity of this crop showed an increasing trend in all the predominantly maize growing states like Punjab, Rajasthan, Gujarat and Andhra Pradesh. Keeping this situation in view, efforts have been made to document viable and profitable technologies of rainfed cereals with collabaration of All India Coordinated Research Projects of Sorghum, Pearlmillet and Fingermillet under different rainfed production systems.

Cropping region

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

Productivity zones

The districts in a crop region vary in productivity, annual normal rainfall and length of growing period. The later two identifies with an agro eco region, while the former with a crop based

production system. By taking these three attributes, a cluster analysis was made and optimum number of clusters were identified. Based on statistical significance, the yield and area growth rates were defined as increasing, decreasing or stagnant.

Yield gap and surplus index of productivity zones

For these cluster of districts, the surplus index (ratio of runoff to average annual normal rainfall) was calculated by (Thornthwaite and Mather method, 1955). The surplus index was divided into three groups – low (less than 12%), medium (12-25%) and high (more than 25%). Necessary soil and water conservation methods were identified. The details follow :

Surplux Index	Possible Options
<12	*In situ* conservation
12-25	*In situ* conservation and water harvesting
>25	Drainage, *in situ* conservation and water harvesting

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

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

Recommendations Domain

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

Recommendations are given for crop based production system, state-wise and cluster(s) of districts. These consist of soil and water conservation, crop management (varieties, seed rate, planting pattern, nutrient management, pest management, suitable cropping systems, farm implements / tools, alternate farming systems and contingent planning. A region was described in terms of agro-geographic setting i.e. climate, physiography, soils, annual rainfall, potential evapo-transpiration (PET) and moisture availability period. The identified priorities for increasing the productivity in short term are also included.

MAIZE BASED PRODUCTION SYSTEM

Maize is grown in 5.19 mha in 346 districts out of which 3.95 mha is rainfed. About 85% of the rainfed area (2.71 mha) is in 67 districts.

Selection Criteria	No. of Districts	Area under Maize ('000 ha)	Area under Rainfed Maize ('000 ha)	Gross Cropped Area ('000 ha)	Yield (kg/ha)
Rainfed States (13)	346	5188	3954	167868	1328
AESR 3-13	261	4100	3196	131273	1366
Cumulative 85% Rainfed Maize Area	67	3047	2710	35416	1352

The trends in area, production and productivity of maize in India (1980 - 2005) are shown in Fig. 1.

The popular production systems in the various agro-eco sub regions are:

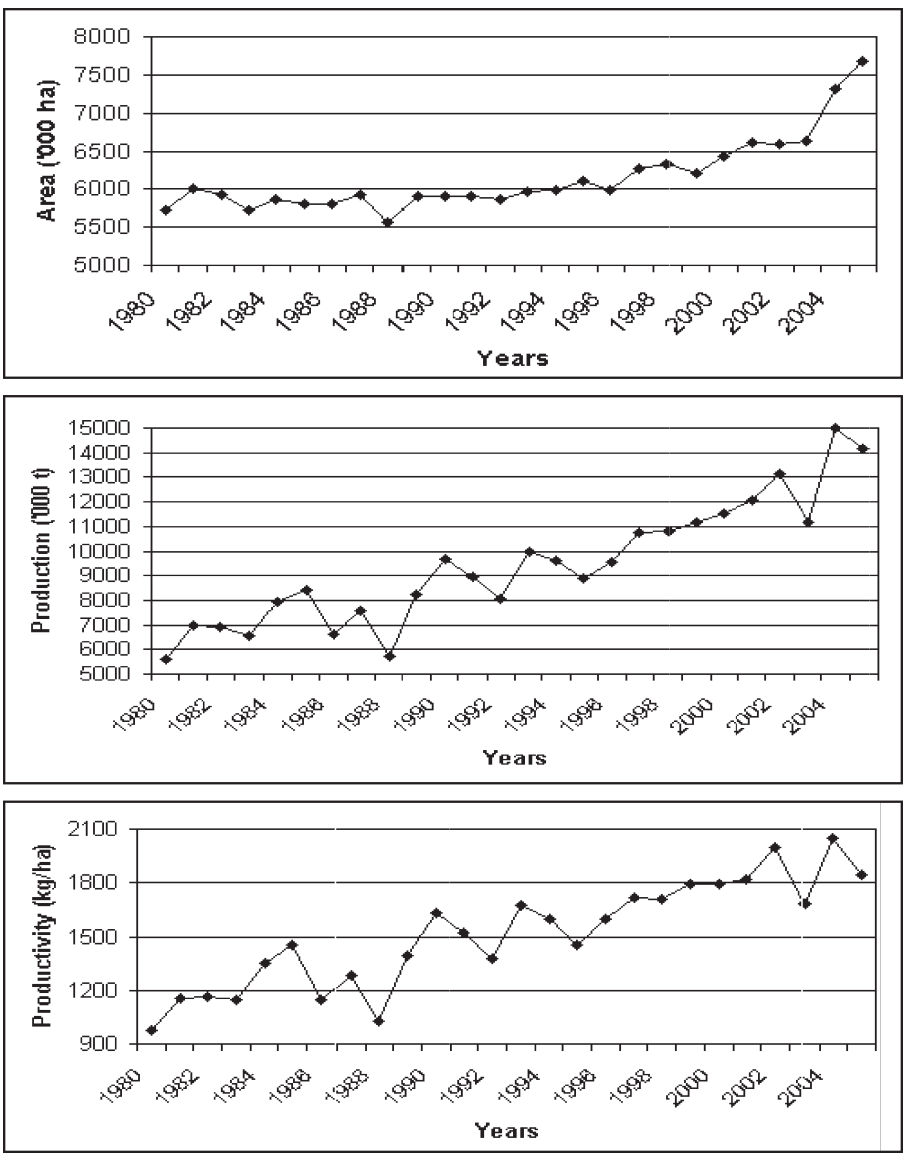
Maize + blackgram
Maize – Chickpea
Maize – Fallow/ chickpea/ safflower
Maize + soybean/ groundnut – safflower
Pigeonpea + maize
Maize – mustard/ chickpea/ wheat
Maize/cowpea – sesamum
Maize + cowpea/ pigeonpea/Yarn
Maize/ Pigeonpea – fallow/wheat
Maize + rajma

Details on associated crops livestock are presented below:

Crops	Animals	Districts
Sorghum	Male Cattle	Bastar, Bilaspur, Surguja, Chhindwara, Mandla, Siddhi, Shahdol,
Soybean	Goats	Guna, Indore, Ratlam, Mandasur, Dewas, Dhar, Jhabua, Khargone,
Maize	Female Cattle	Betul, Shajapur, Nizambad, Medak, Warangal, Karimnagar,
Chickpea	Female Buffalo	Adilabad, Mysore, Shimoga, Dharwad, Dhule, Sabarkantha, Bhundi,
Vegetables	Sheep	Chittorgarh, Jhalawar, Kota, Tonk, Lalitpur, Kheri, Baran, Ganjam,
Fruits	Male Buffalo	Kalahandi, Keonjhar, Koraput, Phulbani, Hazaribagh, Palamur
Maize, Chickpea,	Goats	Shivpuri, Panchmahal, Banswara, Bhilwara,
Pearlmillet, Sorghum,	Male Cattle	Dungarpur, Udaipur, Etah, Buduan, Farukkabad,
Vegetables, Fruits	Female Buffalo	Jaunpur, Ballia, Unnao, Sitapur, Hardoi,
	Female Cattle	Rajsamamund, Kanpur (Dehat), Dumka
	Sheep	
	Male Buffalo	

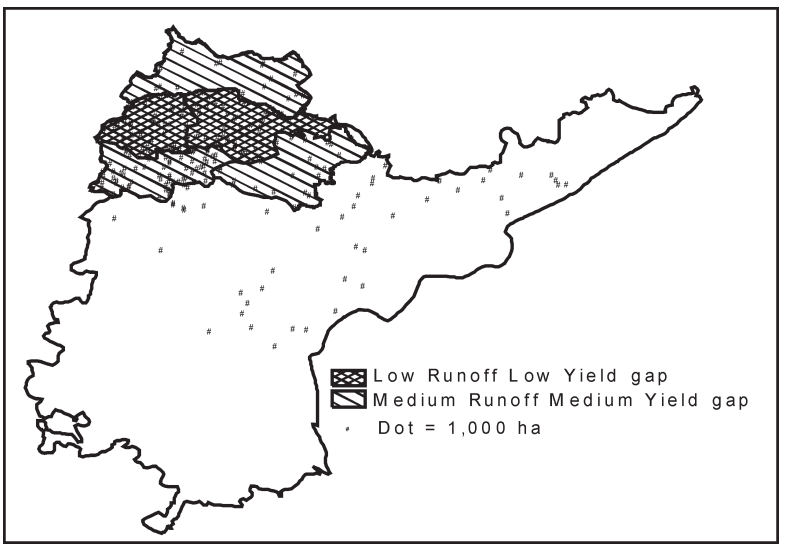
Wheat, Maize, Fruits,	Female Buffalo	Kaira, Gurdaspur, Hoshiarpur, Roopnagar,
Pearlmillet, Vegetables,	Female Cattle	Ambala, Saharanpur
Lentil,	Male cattle	
Potato, Chickpea,	Goats	
Cotton, Sorghum,	Sheep	
Blackgram, Barley,	Male Buffalo	
Soybean, Horsegram		

Fig. 1. Trends in Area, Production and Productivity of Maize in India (1980-2005)



ANDHRA PRADESH

In Andhra Pradesh there are two districts viz. Nizamabad and Karimnagar under low runoff and low yield gap region and three districts viz. Adilabad, Medak and Warangal under medium runoff and medium yield gap region. The trends in area, production and productivity of maize in Andhra Pradesh (1980 - 2005) are shown in Fig. 2.



State	District	Region
Andhra Pradesh	Nizambad and Karimnagar (North West Telangana plateau)	Low runoff and Low yield gap

Agro-geographic setting	Nizambad	Karimnagar
Climate	Hot semi arid	Hot moist semi arid
Soils	Vertic soils – 85 %; Vertisols – 15 %	Vertic soils – 70 %; Vertisols – 30 %
	Shallow and Medium loamy	Deep loamy, Clayey mixed red and black soils
	Medium and deep clayey black soils	
Annual rainfall (mm)	909	880
Potential evapotranspiration (mm)	1802	1802
Length of growing period (LGP) / moisture availability period (days)	120 – 150	120 – 150

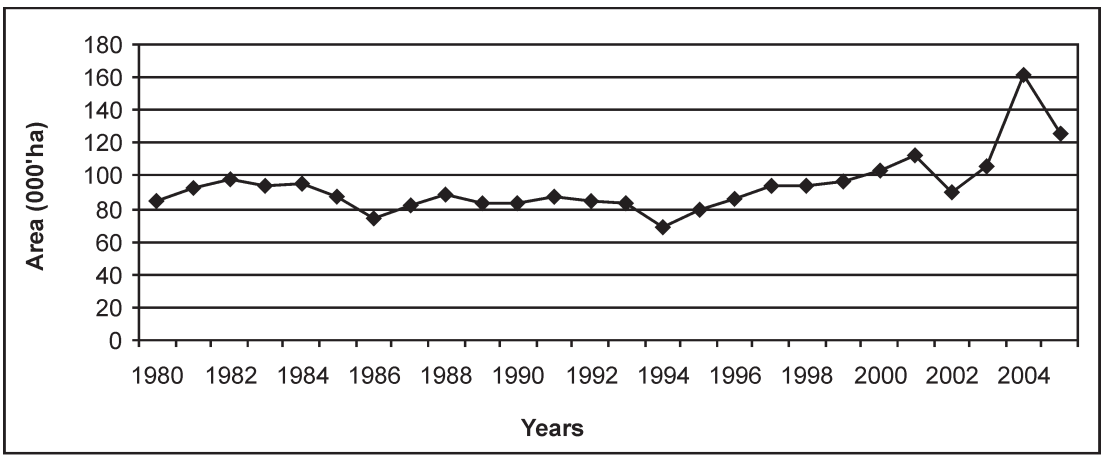
Soil and water conservation

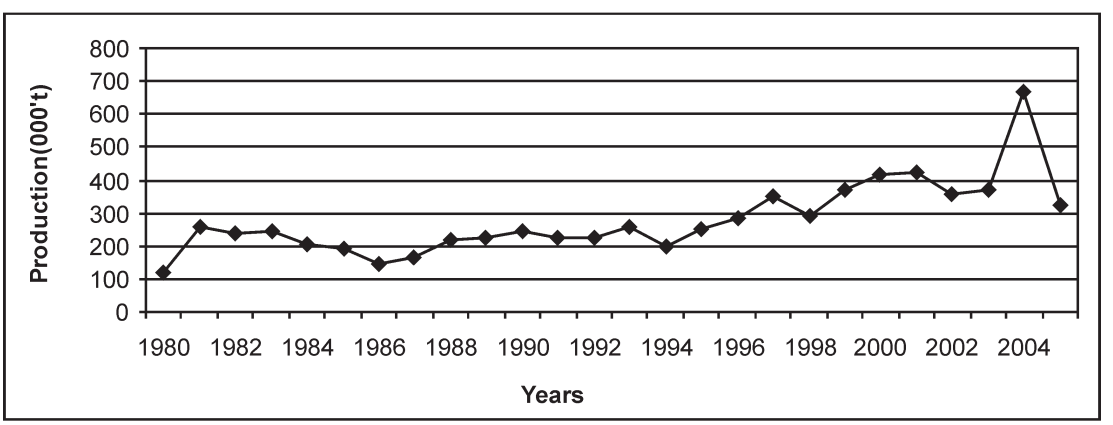
- More emphasis on *in situ* water conservation
- Increasing soil infiltration capacity and reducing soil crusting problem

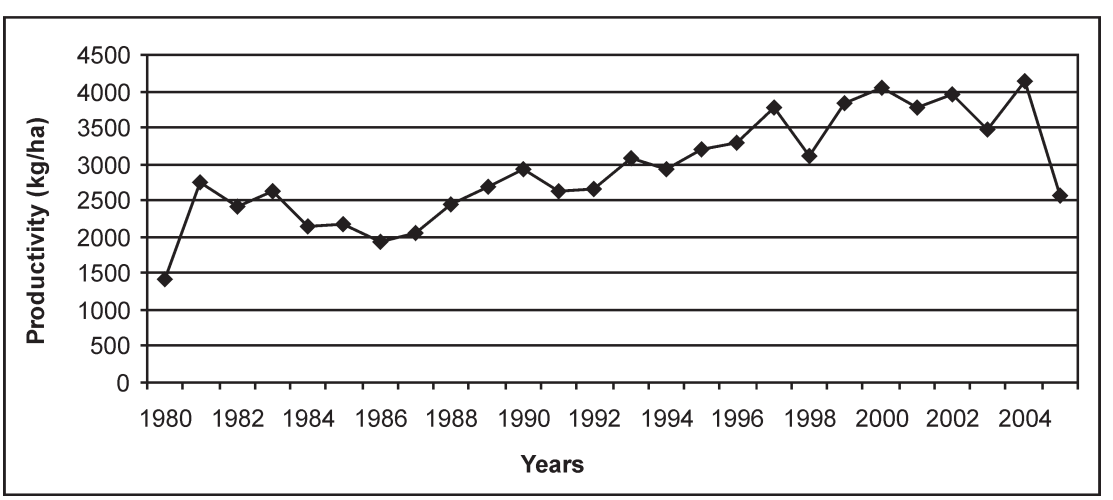
Crop management

- **Varieties :** DHM-1, DHM-107, DHM-109, Ashwini, Harsha, Varun

Fig. 2. Trends in Area, Production and Productivity of Maize in Andhra Pradesh (1980-2005)







- **Seed rate:** 18 kg/ha
- **Planting pattern:** 75 x 20 or 60 x 25 cm
- **Nutrient management**
  - 60 – 80 kg N + 30 - 40 kg P_2O_5 /ha.
  - N in two splits i.e., 50% as basal and 50% at knee high stage
- **Some other important practices**
  - Sowing- *Kharif*-May to June
  - *Rabi* – October to November
  - Seed treatment with thiram 2 to 3 g per kg seed

Suitable cropping systems

- Maize + greengram/blackgram

Farm Implements / tools

- Fertilizer cum seed drill
- Bullock drawn two-row sweep cultivator
- Modified Two-row Blade harrow
- Bullock drawn country plough attached with Pore tube

Alternate farming systems

- **Parkland systems:** *Azadirachta indica, Acacia nilotica, Tamarindus indica*
- **Trees on bunds:** *Tectona grandis*, *Leucaena lecocephala, Borassus flabellifera, Cocos nucifera, Acacia nilotica var. cupressiformis*
- **Silvipstoral system:** *Leucaena leucocephala + Stylosanthes hamata, Leucaena leucocephala + Cenchrus ciliaris*
- **Alley cropping:** *Leucaena leucocephala + sorghum/ Pearlmillet, Gliricidia sepium + sorghum/pearlmillet*
- **Agrohorti system:** Mango + short duration pulses
- **Fruit:** Mango, Ber, Custard apple, Guava, Pomegranate, Amla
- **Fodder/ green biomass:** *Albizzia lebbeck, D.sissoo, Leucaena, Azadiracta, Hardwickia binata, Acacia albida*
- **Fruit:** Custard apple, Tamarind, Jamun, Mango, Ber
- **Medicinal/ Aromatic Plants:** *Cassia angustifolia, Catharanthus roseus, Plantago ovata, Palma rosa, Vetiveria zyzanoides.*
- **Vegetables:** Cluster bean, Drum stick, Cucumber, Cow pea, Ridge gourd, Round melon, Okra, Water melon.

- **Animal component:** Sheep, Goat, Male & Female Cattle

Contingent planning

- **For Red soils**
- **June:**
  - Sole crop: Sorghum (CSH 5, CSH-6, CSH-9) Pearlmillet (MBH-110)
  - Intercrop: Sorghum- pigeonpea (2:1)
  - Pearlmillet + pigeonpea (2:1) in 45 cm row spacing. Pigeonpea duration of 150- 180 days may be used.
- **July:**
  - Sole crop: Fingermillet
  - Bunch variety of Groundnut (TMV-2, JL-24)
  - Intercrop: Maize (DHM-101, Ganga-5)
  - Maize + pigeonpea (2:1) at 50 cm spacing. Pigeonpea duration of 180-200 days
- **August**
  - Sole crop: Setaria (H-1, Arjuna) for grain to poultry feed and straw for fodder
  - Castor (Aruna, GAUCH –1) with increased seed rate (15 kg/ha)
- **For Black soils**
- **First crop**
- **June:**
  - Sorghum (CSH-5, CSH-6)
  - Maize: (Ganga - 5, DHM-101)
  - Greengram (PS-16, HB-45, LRG –30)
- **July:**
  - Maize (Ganga - 5, DHM-101)
  - Greengram (PS-16, HB-45, LRG –30)
- **Second crop**
- **September:**
  - *Maghi* Sorghum (Moti, CSH-6)
  - Safflower: (Manjira)
- **October:**
  - Safflower: (Manjira)
  - Chickpea (Jyothi)
- **Shallow black soils**
  - Only *kharif* cropping is suggested Followed by Greengram – pigeonpea (3:1) in July.

State	District	Region
Andhra Pradesh	Adilabad, Medak and Warangal (North Telangana Plateau)	Medium runoff and Medium yield gap
Agro-geographic setting	**Adilabad**	
Climate	Hot semi arid	
Soils	Vertic soils – 50 %; Sandy Alfisol – 50 %	
	Shallow and Medium loamy	
	Medium and deep clayey black soils	
Annual rainfall (mm)	992	
Potential evapotranspiration (mm)	1689	
Length of growing period (LGP) / moisture availability period (days)	120 – 150	

Soil and water conservation

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

Crop management

- **Varieties** : DHM – 1, DHM-107, DHM-109, Ashwini, Harsha, Varun
- **Seed rate**: 18 kg/ha
- **Planting pattern**: 75 x 20 or 60 x 25 cm
- **Nutrient management**
  - 60 – 80 kg N + 30 - 40 kg P_2O_5/ha.
  - N in two splits i.e., 50% as basal and 50% at knee high stage
- **Some other important practices**
  - Sowing- *Kharif* - May to June
  - *Rabi* – October to November
  - Seed treatment with thiram 2 to 3 g per kg seed

Suitable cropping systems

- Maize + greengram/blackgram
- Maize - chickpea

Farm Implements / tools

- Fertilizer cum seed drill

- Bullock drawn two-row sweep cultivator
- Modified Two-row Blade harrow
- Bullock drawn country plough attached with Pore tube

Alternate farming systems

- **Parkland systems:** *Azadirachta indica, Acacia nilotica, Tamarindus indica*
- **Trees on bunds:** *Tectona grandis, Leucaena lecocephala, Borassus flabellifera, Cocos nucifera, Acacia nilotica var. cupressiformis*
- **Silvipstoral system:** *Leucaena leucocephala + Stylosanthes hamata, Leucaena leucocephala + Cenchrus + ciliaris*
- **Alley cropping:** *Leucaena leucocephala + sorghum/ Pearlmillet, Gliricidia sepium + sorghum/pearlmillet*
- **Agrohorti system:** Mango + short duration pulses
- **Fruit:** Mango, Ber, Custard apple, Guava, Pomegranate, Amla
- **Fodder/ green biomass:** *Albizzia lebbeck, D.sissoo, Leucaena, Azadirachta, Hardwickia binata, Acacia albida*
- **Fruit:** Custard apple, Tamarind, Jamun, Mango, Ber
- **Medicinal/ Aromatic Plants:** *Cassia angustifolia, Catharanthus roseus, Plantago ovata, Palma rosa, Vetiveria zyzanoides.*
- **Vegetables:** Cluster bean, Drum stick, Cucumber, Cow pea, Ridge gourd, Round melon, Okra, Water melon.
- **Animal component:** Sheep, Goat, Male and Female Cattle

Contingent planning

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

- **For Black soils**
- **First crop**
- **June**
  - Sorghum (CSH-5, CSH-6)
  - Maize: (Ganga - 5, DHM-101)
  - Greengram (PS-16, HB-45, LRG –30)
- **July**
  - Maize (Ganga 5, DHM-101)
  - Greengram (PS-16, HB-45, LRG –30)
- **Second crop**
- **September**
  - *Maghi* Sorghum (Moti, CSH-6)
  - Safflower: (Manjira)
- **October**
  - Safflower: (Manjira)
  - Gram (Jyothi)

Agro-geographic setting	Medak	Warangal
Climate	Hot Moist semi arid	Hot Moist semi arid
Soils	Sandy Alfisol – 75 %; Vertic soils – 25 %	Sandy Alfisol – 40 %; Vertic soils – 35 %; Orthids – 25 %
	Deep loamy, Clayey mixed red and black soils	Deep loamy, Clayey mixed red and black soils
Annual rainfall (mm)	835	925
Potential evapotranspiration (mm)	1758	1790
Length of growing period (LGP) / moisture availability period (days)	120 – 150	120 – 150

Soil and water conservation

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

Crop management

- **Varieties/Hybrids** : DHM-1, DHM-107, DHM-109, Ashwini, Harsha, Varun
- **Seed rate**: 18 kg/ha
- **Planting pattern**: 75 x 20 or 60 x 25 cm

- **Nutrient management**
  - 60 – 80 kg N + 30 - 40 kg P_2O_5/ha.
  - N in two splits i.e., 50% as basal and 50% at knee high stage

Some other important practices

- Sowing- *Kharif*-May to June
- *Rabi* – October to November
- Seed treatment with thiram 2 to 3 g per kg seed

Suitable cropping systems

- Maize + greengram/blackgram

Farm Implements / tools

- Bullock drawn two-row sweep cultivator
- Modified Two-row Blade harrow
- Bullock drawn country plough attached with Pore tube

Alternate farming systems

- **Trees on crop lands**
  - **Parkland systems:** *Azadirachta indica, Acacia nilotica, Tamarindus indica*
  - **Trees on bunds:** *Tectona grandis*, *Leucaena lecocephala, Borassus flabellifera, Cocos nucifera, Acacia nilotica var. cupressiformis*
  - **Silvipstoral system:** *Leucaena leucocephala + Stylosanthes hamata, Leucaena leucocephala + Cenchrus + ciliaris*
  - **Alley cropping:** *Leucaena leucocephala + sorghum/ Pearlmillet, Gliricidia sepium + sorghum/pearlmillet*
  - **Agrohorti system:** Mango + short duration pulses
  - **Fruit:** Mango, Ber, Custard apple, Guava, Pomegranate, Amla
- **Fodder/green biomass:** *Albizzia lebbeck, D.sissoo, Leucaena, A.zadiracta, Hardwickia binata, Acacia albida*
- **Fruit:** Custard apple, Tamarind, Jamun, Mango, Ber
- **Medicinal & Aromatic Plants:** *Cassia angustifolia, Catharanthus roseus, Plantago ovata, Palma rosa, Vetiveria zyzanoides.*
- **Vegetables:** Cluster bean, Drum stick, Cucumber, Cow pea, Ridge gourd, Round melon, Okra, Water melon.
- **Animal Component:** Sheep, Goat, and Male & Female Cattle

Contingent planning

- **For Red soils**
- **June**

- Sole crop: Sorghum (CSH-5, CSH-6, CSH-9) Pearlmillet (MBH-110)
- Intercrop: Sorghum- pigeonpea (2:1)

  Pearlmillet + pigeonpea (2:1) in 45 cm row spacing. Pigeonpea duration of 150- 180 days may be used.

- **July**
  - Sole crop: Fingermillet

    Bunch variety of Groundnut (TMV-2, JL-24)
  - Intercrop: Maize (DHM-101.Ganga-5)

    Maize + pigeonpea (2:1) at 50 cm spacing. Pigeonpea duration of 180-200 days
- **August**
  - Sole crop: Setaria (H-1, Arjuna) for grain to poultry feed and straw for fodder
  - Castor (Aruna, GAUCH –1) with increased seed rate (15 kg/ha)
- **For Black soils**
- **First crop**
- **June**
  - Sorghum (CSH-5, CSH-6)
  - Maize: (Ganga-5, DHM-101)
  - Greengram (PS-16, HB-45, LRG –30)
- **July**
  - Maize (Ganga-5, DHM-101)
  - Greengram (PS-16, HB-45, LRG –30)
- **Second crop**
- **September**
  - *Maghi* Sorghum (Moti, CSH-6)
  - Safflower: (Manjira)
- **October**
  - Safflower (Manjira)
  - Chickpea (Jyothi)

CHATTISGARH

In Chattisgarh there is one district viz. Bilaspur under high runoff and medium yield gap region. and one district viz. Surguja undar high run off and high yield gap region.

State	District	Region
Chattisgarh	Bilaspur (Chattisgarh/ Mahanandi Basin)	High runoff and medium yield gap

Agro-geographic setting	Bilaspur
Climate	Hot moist / dry sub humid
Soils	Ustalf/Ustolls –100%, Deep loamy to clayey red and yellow soils
Annual rainfall (mm)	1327
Potential evapotranspiration (mm)	1475
Length of growing period (LGP) / moisture availability period (days)	150 – 180

Soil and water conservation

- Sowing across the slope
- Contour farming

Crop management

- **Varieties :** Satha, Chandan - 2, Chandan - 3, Ganga - 5, JK-1, JK – 41, JK - 62
- **Seed rate:** 15 – 18 kg/ha
- **Planting pattern:** 60 x 30 cm
- **Nutrient management**
  - 40 kg N + 40 kg P_2O_5/ha for desi Maize.
  - 80 kg N + 60 kg P_2O_5/ha for hybridesi Maize.
  - Full quantity of P and half dose of N should be applied at sowing and half dose of N at after first weeding

Alternate Farming systems

- **Agro – hortisystem:** Mango + Pea / Berseem (green fodder) / Wheat/ gram / soybean
- **Silvi – pastoral system :** Teak + sudan gram
- **Fodder/green biomass***: A. lebbeck, Leucaena, D.sissoo, A.indica, Sesbania, Pongamia*
- **Fruit:** Ber, Mango Sapota, Tamarind, Fig
- **Medicinal & Aromatic Plants:** *Papaver somniferum, Rauvolfia, Liquorice, Safedmusli, Palma rosa*
- **Vegetables:** Tomato, Okra, Bottle gourd, Ridgegourd, Amaranthus, Drumstick
- **Animal component:** Female Cattle, Male Cattle, Female Buffaloes, Male Buffaloes

Contingent planning

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

State	District	Region
Chattisgarh	Surguja (Northern Chattisgarh)	High runoff and High yield gap

Agro-geographic setting	Surguja
Climate	
Soils	Ustalf/Ustolls – 100%
Annual rainfall (mm)	1406
Potential evapotranspiration (mm)	1471
Length of growing period (LGP) / moisture availability period (days)	

Soil and water conservation

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

Crop management

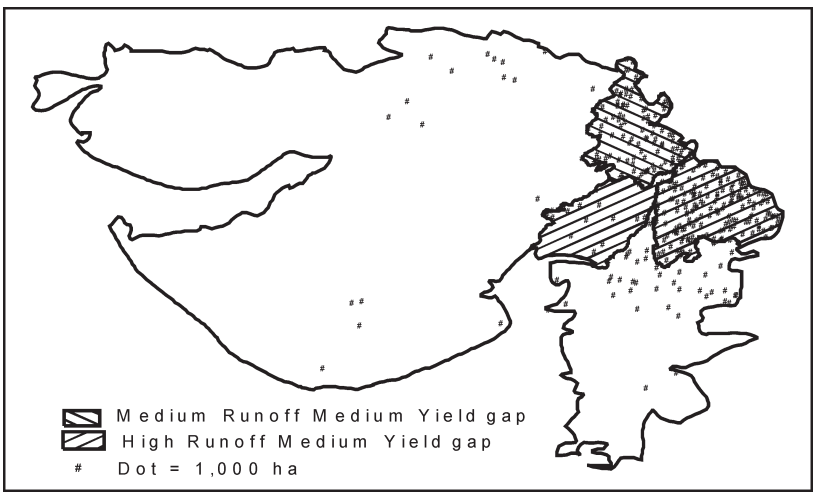
- **Varieties :** Satha, Chandan - 2, Chandan - 3, Ganga - 5, JK-1, JK – 41, JK - 62
- **Seed rate:** 15 – 18 kg/ha
- **Planting pattern:** 60 x 30 cm
- **Nutrient management**
  - 40 kg N + 40 kg P_2O_5/ha for desi Maize.
  - 80 kg N + 60 kg P_2O_5/ha for hybridesi Maize.
  - Full quantity of P and half dose of N should be applied at sowing and half dose of N at after first weeding

Alternate farming systems

- **Agro – hortisystem:** Mango + Pea / Berseem (green fodder) / Wheat/ gram / soybean
- **Silvi – pastoral system :** Teak + sudan gram
- **Fodder/green biomass:** *Leucaena leucocephala, Albizzia amara, Dichrostachys cineria, Melia azadirachta, Hardwickia binata, A.lebbeck*
- **Fruit:** Mango, Ber, Guava, Tamarind, Karonda
- **Medicinal & Aromatic Plants:** *Safed musli, Palma rosa, Withania somnifera, Papaver somniferum, Vetiveria zyzanoides*
- **Vegetables:** Brinjal, Chilli, Cowpea, Okra, Bottle gourd, round melon.
- **Animal component:** Female Cattle, Male Cattle, Female Buffaloes, Goats

GUJARAT

In Gujarat there are three districts viz. Sabarkanta, Kaira and Panchmahals under medium runoff and medium yield gap region. The trends in area, production and productivity of maize in Gujarat (1980 - 2005) are shown in Fig. 3.



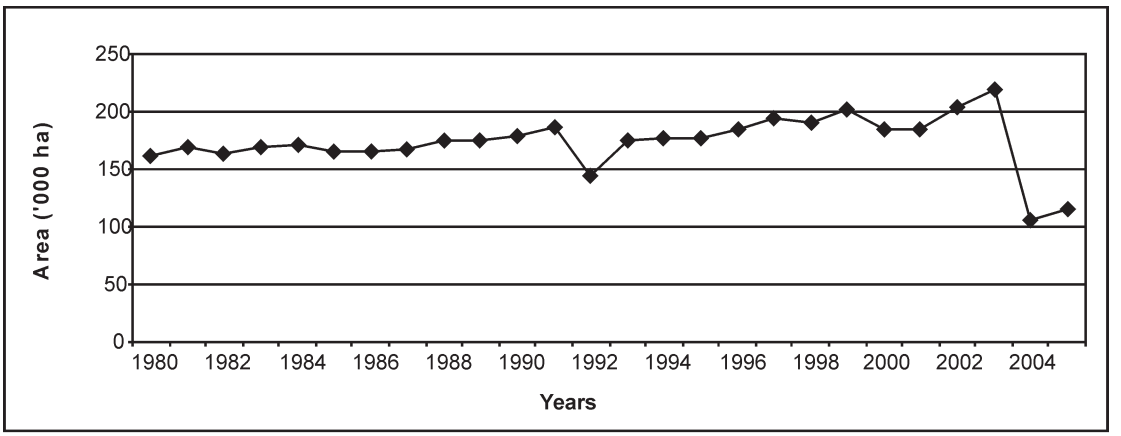
State	District	Region
Gujarat	Sabarkantha (North Gujarat Plains) Kaira and Panchmahals (Eastern Gujarat Plain)	Medium runoff and Medium yield gap

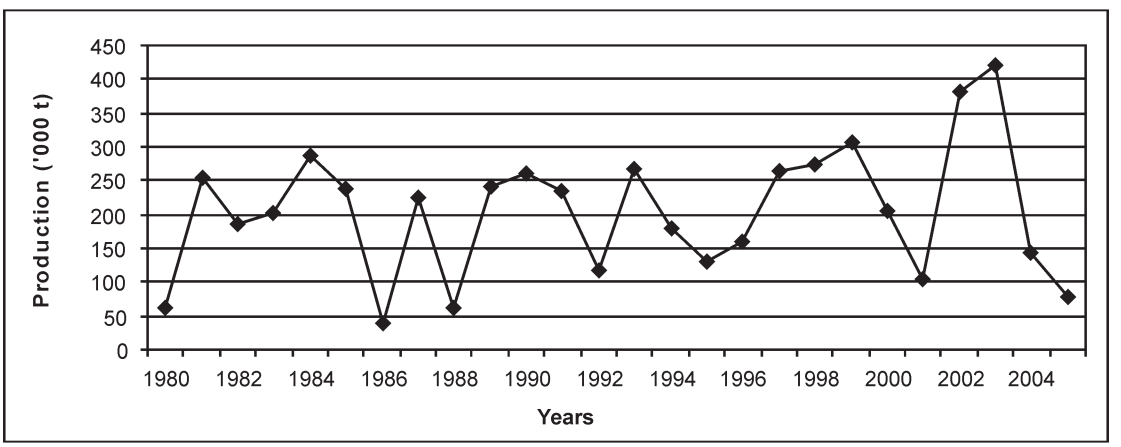
Agro-geographic setting	Sabarkantha	Kaira	Panchmahals
Climate	Hot dry semi arid	Hot moist semi arid	Hot moist semi arid
Soils	Vertic soils – 50%; Ustalf/Ustolls – 50%	Ustalf/Ustolls – 60%; Vertic soils – 40%	Vertic soils – 100%
	Deep loamy grey brown and alluvium - derived soils	Deep clayey black soils, Shallow black soils	Deep clayey black soils, Shallow black soils
Annual rainfall (mm)	885	929	833
Potential evapotranspiration (mm)	1608	1596	1560
Length of growing period (LGP) / moisture availability period (days)	90 – 120	120 – 150	120 – 150

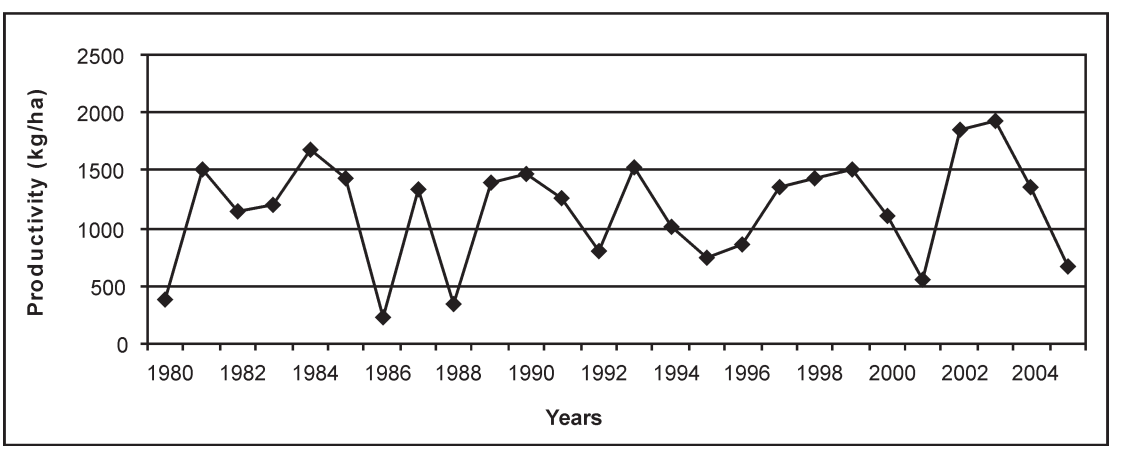
Soil and water conservation

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

Fig. 3. Trends in Area, Production and Productivity of Maize in Gujarat (1980-2005)







Crop management

- Locally available suitable varieties may be adopted.

Alternate farming systems

- **Agro-horti system :** Ber + sorghum/green gram were grown between two rows of ber
- **Fodder/green biomass:** The farmers growing Ber(10x6m) on light textured soils are advised to take inter crop of either greengram or sorghum (fodder) *A.lebbeck, A. indica, A albida, Cassia siamia, D.sissoo, Alianthus excelsa*
- **Fruit:** Mango, Pome granate, Guava, Ber, Fig, Jamun
- **Medicinal & Aromatic Plants***: Plantago ovata, Cassia angustifolia, Liquorice*
- **Vegetables:** Drumstick, Cluster bean, Cowpea, Long melon, Okra
- **Animal component:** Female Cattle, Male Cattle, Female Buffaloes, and Goats

Contingent planning

- **Normal sowing (Early July)**

Crops	Varieties/ hybrids
Castor	GCH-4, GCH-5, GCH-6
Pearlmillet	GHB-235, GHB-316
Cowpea	Guj. Cowpea-4
Clusterbean	Guj. Clusterbean-1
Greengram	Guj. Mung-4
Sorghum	GSF-4
Mothbean	Guj-1
Karingado	Guj. Karingado-1

- **Delayed sowing (15th July to early August)**

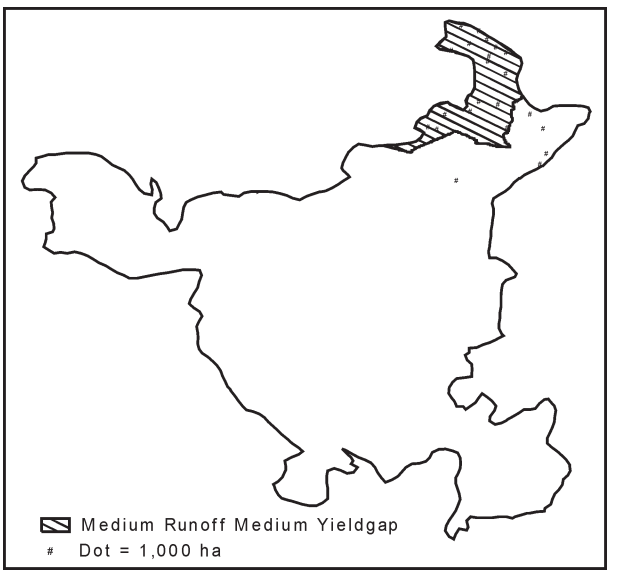
Crops	Varieties
Castor	GCH-4
Sorghum	GSF-4
Cluster bean	Guj. Clusterbean-1

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

Crop	Varieties
Castor	GCH-4

HARYANA

In Haryana there is one district viz. Ambala under medium runoff and medium yield gap region.



State	District	Region
Haryana	Ambala (North East Haryana)	Medium runoff and Medium yield gap

Agro-geographic setting	Ambala
Climate	Hot dry/ moist sub humid (transitional)
Soils	Inceptisols – 100 %
	Deep loamy to clayey alluvium - derived soils
Annual rainfall (mm)	959
Potential evapotranspiration (mm)	1482
Length of growing period (LGP) / moisture availability period (days)	120 – 150

Soil and water conservation

- Increasing soil infiltration capacity and reducing soil crusting problem
- Inter-plot water harvesting of 1:1 cropped to uncropped land
- Dead furrows at 3.6 m intervals
- Land shaping
- Pre monsoon/ summer tillage and ridge furrow configurations across the land slope to improve moisture storage.

Crop management

- Locally available suitable hybrids may be adopted.

Farm Implements / tools

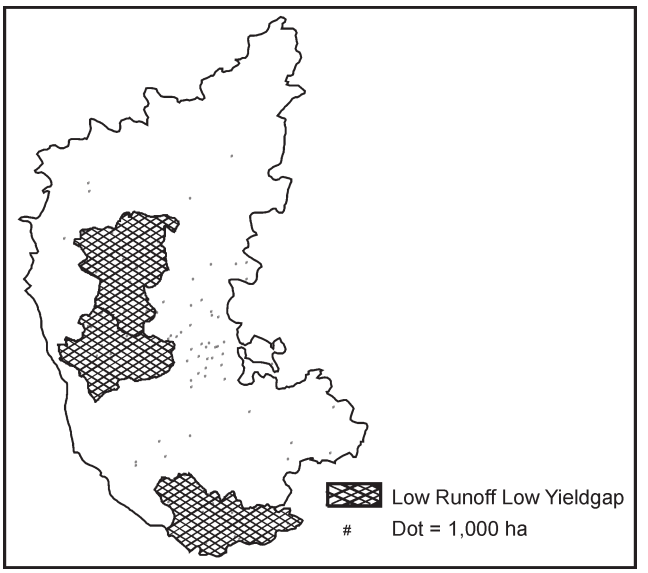
- Use of blade type wheel hand hoe to save time and energy for interculture operations
- Tractor – drawn ridger –seeder (3 Point hich tools)
- Bullock-drawn Ridger seeds
- Bullock-drawn interculture blade harrow
- Hand wheel Hoe

Alternate farming systems

- **Agrohortisystem:** Ber + cowpea/greengram/clusterbean/Aryan grass
- **Fodder/ green biomass:** Agri-Horti system of ber intercropped with cowpea, greengram, clusterbean and anjan grass.
- *A.lebbeck P.cineraria, Melia azadirachta [for saline soils], D.sissoo, A.indica.*
- **Fruit:** Guava, Amla, Karonda, Phalsa, Bael, Jamun
- **Medicinal & Aromatic Plants***: Plantago ovata, Palma rosa, Vetiveria zyzanoides, Ocimum viride, Liquorice.*
- **Vegetables:** Tomato, Chillies Okra, Cowpea, Palak, Bottle gourd
- **Animal Component:** Female Buffaloes, Sheep

KARNATAKA

In Karnataka there are three districts viz. Dharwad, Shimoga, and Mysore under low runoff and low yield gap region.



State	District	Region
Karnataka	Dharwad (Western Karnataka plateau) Shimoga (Central West Karnataka) Mysore (Southern Karnataka plateau)	Low runoff and Low yield gap

Agro-geographic setting	Dharwad	Shimoga
Climate	Hot dry sub humid	Hot moist semi arid Hot moist sub humid to humid (transitional)
Soils	Vertic soils – 70%; Vertisols – 30%	Sandy Alfisols – 100%
	Shallow and medium loamy and clayey black soils, Deep clayey black soils	Medium to deep red loamy soils, Deep loamy to clayey red and lateritic soils
Annual rainfall (mm)	813	1045
Potential evapotranspiration (mm)	1665	1381
Length of growing period (LGP) / moisture availability period (days)	150 – 180	120 – 270

Soil and water conservation

- Rubbles at 0.3 m vertical interval on contour key lines
- Compartmental bunding, ridges and furrows, contour cultivation

- Planting Khus grass and subabul in paired rows at vertical interval of 0.3 m
- Bund stabilisation through *stylosanthes* slope
- 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
- *In-situ* moisture conservation practices like compartmental bunding, ridges and furrows contour cultivation and fall ploughing helped to conserve more moisture in deep black soils.

Farm Implements / tools

- In shallow and marginal eroded soils, growing of agave and subabul is advocated

Alternate farming systems

- **Fodder/green biomass***: D.sissoo, Glyricidia, A.lebbeck, H.binata, Cassia siamea, Azadirachta indica*
- **Fruit:** Cultivation of mango, ber, sapota and curry leaf in the zing conservation bench terraces, waterways and on the embankment of farm ponds. Mango, Pomegranate, Sapota, Ber, Jamun, Tamarind
- **Medicinal & Aromatic Plants:** *Cassia angustifolia Catharanthus roseus, Palma rosa, Vetiverie zyzanoides, Rose, Geranium,*
- **Vegetables:** Onion, Brinjal, chillies, Cowpea, Cucumber, Cluster bean, Drumstick.
- **Animal Component:** Female and male Cattle, Female Buffaloes, Goat, Sheep and Poultry

Mysore (Southern Karnataka plateau)

Agro-geographic setting	Mysore
Climate	Hot moist semi arid
Soils	Sandy Alfisol – 100 % Medium to deep red loamy soils
Annual rainfall (mm)	920
Potential evapotranspiration (mm)	1535
Length of growing period (LGP) / moisture availability period (days)	120 – 150

Soil and water conservation

- More emphasis on *in situ* water conservation
- Reducing soil crusting problem
- Dead furrows at 3.6 m interval
- Farm pond size of 250m^3 plastered both sides and bottom with cement + sandy clay soils (1:8)
- Opening furrows on 0.2 to 0.4 slope
- Summer tillage

- The existing bund itself could be modified to act as graded bund by internal land smoothening open end contour bunds (0.8 m^2) or graded bunds (0.36 m^2) on a slope of 0.2 to 0.4%. Waterways are a viable with outlets.
- Developing deeper soil (<45 cm) in to graded border strips of 10-12 m width on a gradient of 0.2 to 0.4 percent along the length
- Alleviation of crust is possible with the addition of 10 t FYM/ha, 5 tones maize residue/ha and 25 sand t/ ha

Crop management

- **Varieties:** Ganga-11, Deccan-103, Vijay composite, NAC 6004 (Composite), NAC 6002 (Composite)
- **Seed rate:** 15 kg/ha

  Fodder Maize – 100 kg/ha
- **Planting Pattern:** 60 or 75 x 20 cm

  30 x 10 cm
- **Nutrient management**
  - 10 t FYM/ha + 75kg N + 50 kg P_2O_5 + 25 kg K_2O +10 kg zinc sulphate /ha.
  - N in 2 splits, ½ at sowing and ½ at knee high stage. Place P 5 cm deep from the seed
  - For Fodder Maize: 5 t FYM/ha + 37. 5kg N + 50 kg P_2O_5 + 38 kg K_2O +10 kg zinc sulphate and apply N in 2 splits, ½ at sowing and ½ at knee high stage. Place P 5 cm deep from the seed

Suitable cropping systems

- Pigeonpea - maize (1:1)

Tools/Implements	Cost/Unit (Rs.)	Operation
Bullock drawn seed-cum-fertilizer drill (Finger millet)	1500/-	Bullock drawn manual operation for finger millet seeding and fertilizer application (Hand metered)
Bullock drawn seed-cum-fertilizer drill (Groundnut)	1500/-	Groundnut seeding with fertilizer application
Multi furrow opener	1300/-	Opening furrows for hand seeding of different crops
Bent tyne hoe	350/-	Intercultural operation for finger millet
Duck foot hoe	350/-	Intercultural operation for finger millet and groundnut for moisture conservation (Hand metered)
Crust brakes	500/-	For breaking the crust to facilitate smooth emergence of the seedling in finger millet and groundnut.

Farm Implements / tools

Alternate farming systems

- **Fodder/green biomass:**
  - *Cassuarina and silver Oak are better suited than other three species like eucalyptus, neem, Leucaena,*

Acacia etc.

- *Faidherbia albida is more suitable for planting on bunds (E-W direction) in micro-watershed.*
- Stylosanthes hamata is most suitable. *Stylosanthes scabra* should be adopted for gravelly shallow soils with low rainfall.
- *Acacia auriculiformis, Cassia siamea, Dalbergia sissoo,* subabul and amla are more suitable and promising than other deep-roted high water intensive tree species under high gradient non-arable lands with shallow soils and rock out crops. For better establishment, trench method of planting is better than pit method.
- Bamboo, Jambulina, pongamia, neem*, Albizzia lebbeck*, peepal, and ficus species can be planted in the catch pits and pockets of deep soil.
- Grasses *like Pennisetum pedicellatum or Cenchrus ciliaris* and legumes like *Microtelium axillaries* are suitable forage species.
- *L.leucocephala, Albizzia lebbeck, Dalbergia sissoo, A.indica, Pongamia, Cassia siamea*

- **Fruit:**
  - In suit grafting/ budding of fruits trees like mango and ber found to be more economical than using grafted plants.
  - Custard apple, Jack and tamarind were other species suitable to waste lands.
  - Mango, Phylanthus and Jambulina performed better in the non-arable land.
  - Mango, Pomegranate, Sapota, Guava, Custard apple, Jamun
- **Medicinal & Aromatic Plants:** *Catharanthus roseus, Cassia angustifolia, Solanum viarum, Dioscorea, Geranium, Pogostemon patchouli, Jasmine*
- **Vegetables:** Tomato, Chillies, Okra Water melon, Bitter gourd, Drum stick, Brinjal, Bitter gourd
- **Animal component:** Female Cattle, Male Cattle, Female Buffaloes, Sheep, Goat and Poultry

Month and Fortnight (FN) in which normal rains occur	Crops that could be sown	
	Monocropping	Double cropping
April-II FN		Sesame or greengram
May I FN	Pigeonpea	Sesame, cowpea, greengram, blackgram, Fodder maize, Fodder Pearl millet, Fodder sorghum
May-II FN	Pigeonpea	Sesame, cowpea, greengram, blackgram, Fodder maize, Fodder Pearl millet, Fodder sorghum
June-I FN	Long duration Finger millet, Pigeonpea, Maize, Groundnut	Fodder maize, Fodder sorghum, Fodder pearl millet, Cowpea
June-II FN	Long duration Finger millet, pigeonpea, Maize and Groundnut	Sowing of chilli nursery
July-I FN	Groundnut, long duration finger millet	Sowing of Chilli nursery
July-II FN	Groundnut, long/medium duration fingermillet	Sowing of Chilli nursery

August-I FN	Cowpea, Horsegram, short duration finger millet, transplanting chilli short duration finger millet.	Cowpea, Horsegram, short duration finger millet, transplanting chilli. Sowing of chilli nursery and
August II FN	Short duration finger millet, transplanting of medium and long duration finger millet. Transplanting chilli. Cowpea, Horsegram	Short duration fingermillet, transplanting of medium and long duration finger millet, transplanting chilli. Cowpea. Horsegram. Also, Fodder crops (Maize-Pearl millet, sorghum)
September I FN	Horsegram, Transplanting of short duration finger millet and chilli (with protective irrigation)	Horsegram, Transplanting of short duration finger millet and chilli (with protective irrigation)

Contingent Planning

Alternate /Contingency crop production practices for drought mitigation

- Dry sowing in finger millet, sorghum, maize, pigeonpea, groundnut and castor when monsoon is delayed. For crops with big seeds and less seed rate, like pigeonpea, pelletisation of seed is to be done before dry sowing.
- Maintain optimum plant population by thinning.
- Repeated inter cultivation coupled with weeding and weed mulching.
- Preventive measures against pests and diseases.
- Double split top dressing.
- Controlled grazing by animals to reduce excess vegetative growth to prevent transpiration in finger millet and horsegram

MADHYA PRADESH

In Madhya Pradesh there are four districts viz. Chhindwara, Khargone, Mandsaur and Shajapur under medium runoff and medium yield gap region, seven districts viz. Betul, Dewas, Jhabua, Ratlam, Indore, Sidhi and Shivapure under high runoff and high yield gap region, one district viz. Mandla under high runoff and medium yield gap region and two districts viz. Guna and Sahadol under high runoff high yield gap region.

State	District	Region
Madhya Pradesh	Chhindwara (Southern Madhya Pradesh) Khargone (Madhya Bharat Plateau) Mandsaur (Western Malwa Plateau) Shajapur (Malwa Plateau)	Medium runoff and Medium yield gap

Agro-geographic setting	Chhindwara	Khargone	Mandsaur	Shahjapur
Climate	Hot moist sub humid		Hot moist semi arid	Hot moist semi arid Hot dry sub humid
Soils	Vertic soils – 85 %; Vertisols – 15% Shallow to deep loamy to clayey mixed red and black soils	Vertic soils – 100% Shallow black soils, medium and deep clayey black soils, shallow loamy soils	Vertic soils – 100% Deep clayey black soils Shallow black soils	Vertic soils – 90%; Vertisols – 10 % Deep clayey black soils Shallow black soils Medium and deep clayey black soils Shallow loamy black soils
Annual rainfall (mm)	1094	888	962	1117
Potential evapotranspiration(mm)	1427	1792	1601	1643
Length of growing period (LGP)/ moisture availability period (days)	180 – 210	120 – 180	120 – 150	120 - 180

Soil and water conservation

- Broad bed furrow (BBF) for soybean
- Gabion structures in waterways
- Graded border strips
- Sowing across the slope and ridging later
- Compartmental bunding
- Mulching
- 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.
- Develop a sort of terracing to break the continuity of undulating slope to reduce the changes of degrading cultivated fields in to gullied one.
- 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.

- 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 retrain the excess run off from the watershed area to use stored water for irrigation purpose.
- Silpaulin (a plastic material) of 90 – 120 gsm has been found 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 gullied one.
- Use mould board plough for deep tillage to increases the productivity of *kharif* crops and ensure sowing of *rabi* crop through better moisture conservation and eradication of infested weeds.
- Ensure drainage line treatment for providing safe disposal of excess run off and providing more opportunity time in order to reduce erosive velocity.
- Graded bunds alone and / or along with vegetative barriers at vertical intervals of 50 cm proves most effective in controlling soil erosion and nutrient losses on soils having slope up to 2 per cent.
- Off-season shallow tillage is important not only in controlling the weeds but also in helping entry of rain water.

Crop management

- **Varieties :** JM 8 , JM 12, Navjot, Chandan 3, Chandan Safed, NLD

  Hybrids: Ganga - 5, Deccan - 107, Deccan - 109 and KH - 510
- **Seed rate:** Composites 18 -20 kg /ha

  Hybrids: – 16 – 18 kg /ha
- **Planting pattern:** 60 x 20 cm, 75 x 20 cm
- **Nutrient management**
  - Composites: 80 kg N + 60 kg P_2O_5 + 20 kg K_2O. Apply 50 % N as basal and 50 % in two split at knee height and tasseling
  - Hybrids: 100 kg N + 60 kg P_2O_5 + 20 kg K_2O. Apply 50 % N as basal and 50 % in two split at knee height and tasseling

Some other important practices

- Seed treatment with thiram @ 3 g/kg seed.
- Sowing on onset of monsoon

Suitable cropping systems

- Monocropping of Maize (for cobs) in *kharif* in shallow black soils
- Maize + chickpea + safflower in deep black soils

Farm Implements / tools

- **Suitable Implements For Seedbed Preparations:**
  - Meston Plough
  - Iron Bakhar
- **Suitable Implements For Sowing Operations:**
  - Mahakal Dufan
  - Mahakal Tifan and
  - Sarta attachment for intercropping
- **Suitable Implements / Tools For Interculture Operations:**
  - hand dora (small blade harrow)
  - Bullock drawn dora (small blade harrow with wooden beam)
  - Indore ridger

Alternate farming systems

- **Trees on croplands :**
- **Fodder/green biomass:** *Dichrostachys cineria, Albizzia amara, Faidherbia albida, Hardwickia binata, Cassia, Leucaena leucocephala, Albizzia lebbeck*
- **Fruit:** Ber, Pomegranate, Mango, Fig, Tamarind
- **Medicinal & Aromatic Plants:** *Withamnia somnifera, Rauvolfia serpentina, Vetiveria zyzanoides, Palma rosa, Liquorice.*
- **Vegetables:** Chillies, Okra, Watermelon, Cowpea, Cluster bean, Amaranth, round melon.
- **Animal component:** Female and male Cattle, Female Buffaloes, Goat and Poultry

Contingent planning

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:

Period	Crops and their varieties recommended for planting
(A) 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 – Gauch and Varuna. Fodder crops – Sorghum sudanensis, Maize- African tall, Dinanath grass and Pearlmillet etc.

(B) 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 (Ameranthus)- Co-1 and Co-2. Castor- Gauch, Varuna. Fodder crops – Sorghum Sudanensis, Maize- African tall, Dinanath grass and Pearl millet etc.
(C) 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- Gauch, Varuna. Fodder crops – Barley, oats ,Maize- African tall, safflower and sunflower.

State	District	Region
Madhya Pradesh	Betul (Southern Madhya Pradesh) Dewas, Jhabua and Ratlam (Central West Madhya Bharat Plateau) Indore (Narmada valley) Sidhi (Vindhian Scraplands) Shivapure (Madhya Bharat Plateau)	High runoff and High yield gap

Agro-geographic setting	Betul	Dewas	Jhabua	Ratlam	Indore
Climate	Hot dry sub humid	Hot dry moist semi arid	Hot moist semi arid	Hot moist semi arid	Hot moist semi arid
Soils	Vertic soils–85%; Vertisols – 15 % Shallow and medium loamy to clayey black soils Deep clayey black soils	Vertic soils–100% Deep clayey black soils Shallow black soils Medium and deep clayey black soils Shallow loamy black soils	Vertic soils–100% Deep clayey black soils Shallow black soils	Vertic soils–100% Deep clayey black soils Shallow black soils	Vertic soils–100% Deep clayey black soils Shallow black soils
Annual rainfall (mm)	1129	1079	768	1078	1054
Potential evapotranspiration (mm)	1370	1707	1610	1521	1814
Length of growing period (LGP) / moisture availability period (days)	150 – 180	120 – 180	120 – 150	120 – 150	120 – 150

Soil and water conservation

- Straighten the gullied portion in the farmers' fields through earth moving machinery to reduce the length of gully allowing safe passage for the run off water. It brings additional area under cultivation through reclamation process.
- Construct percolation tank for increasing ground water recharge and enhancing ground water storage to provide extra irrigation to the crops.

- Use gabion as an inlet and outlet of water harvesting tank without any structural failure to trap silt on the upstream sit to increase life of water storage bodies.
- Construct water-harvesting tank to retrain the excess run off from the watershed area to use stored water for irrigation purpose.
- Silpaulin (a plastic material) of 90 – 120 gsm has been found 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 gullied one.
- Use mould board plough for deep tillage to increases the productivity of *kharif* crops and ensure sowing of *rabi* crop through better moisture conservation and eradication of infested weeds.
- Ensure drainage line treatment for providing safe disposal of excess run off and providing more opportunity time in order to reduce erosive velocity.
- Mould board plough, used for deep tillage to increase the productivity of *kharif* crops and enhance sowing of *rabi* crops through better moisture conservation and eradication of infested weeds.
- Graded bunds alone and / or along with vegetative barriers at vertical intervals of 50 cm proves most effective in controlling soil erosion and nutrient losses on soils having slope up to 2 per cent.
- Off-season shallow tillage is important not only in controlling the weeds but also in helping entry of rain water.
- 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.

Crop management

- **Varieties :** JM - 8, JM - 12, Navjot, Chandan 3, Chandan Safed, NLD, Ganga - 5, Deccan - 107, Deccan - 109, KH - 510
- **Seed rate:** Composites 18 -20 kg /ha

  Hybrids: – 16 – 18 kg /ha
- **Planting Pattern:** 60 x 20 cm, 75 x 20 cm
- **Nutrient management**
  - Composites: 80 kg N + 60 kg P_2O_5 + 20 kg K_2O/ha. Apply 50 % N as basal and 50 % in two splits at knee height and tasseling
  - Hybrids: 100 kg N + 60 kg P_2O_5 + 20 kg K_2O/ha. Apply 50 % N as basal and 50 % in two splits at knee height and tasseling

Some other important practices

- Seed treatment with Thiram @ 3 g/kg seed.

Suitable cropping systems

- Monocropping of Maize (for cobs) in *kharif* in shallow black soils
- Maize + chickpea + safflower in deep black soils

Farm Implements / tools

- **Suitable Implements for seedbed preparations**
  - Meston Plough
  - Iron Bakhar
- **Suitable Implements for sowing operations**
  - Mahakal Dufan
  - Mahakal Tifan and
  - Sarta attachment for intercropping
- **Suitable Implements / Tools for interculture operations**
  - Hand dora (small blade harrow)
  - Bullock drawn dora (small blade harrow with wooden beam)
  - Indore ridger

Alternate farming systems

- **Trees on crop lands**
- **Fodder/green biomass:** *Dichrostachys cineria, Albizzia amara, Faidherbia albida, Hardwickia binata, Cassia, Leucaena leucocephala, Albizzia lebbeck*
- **Fruit:** Ber, Pomegranate, Mango, Fig, Tamarind
- **Medicinal & Aromatic Plants:** *Withamnia somnifera, Rauvolfia serpentina, Vetiveria zyzanoides, Palma rosa, Liquorice.*
- **Vegetables:** Chillies, Okra, Watermelon, Cowpea, Cluster bean,
- Amaranth, round melon.
- **Animal component:** Female Cattle, Male Cattle, Female Buffaloes, Goat and Poultry

Contingent Planning

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:

Period	Crops and their varieties recommended for planting
(A) 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. Cow pea – Pusa Komal and Pusa Baisakhi. Castor – Gauch and Varuna. Fodder crops – Sorghum sudanensis, Maize- African tall, Dinanath grass and Pearlmillet etc.

(B) 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- Gauch,Varuna. Fodder crops – Sorghum Sudanensis, Maize- African tall, Dinanath grass and Pearlmillet etc.
(C) 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- Gauch, Varuna. Fodder crops – Barley, oats, Maize- African tall, safflower and sunflower

State	District	Region
Madhya Pradesh	Sidhi (Vindhian Scraplands)	High run off and High yield gap

Agro-geographic setting	Sidhi
Climate	Hot dry sub humid
Soils	Ustalf/Ustolls – 75%; Vertic soils – 25% Deep loamy to clayey mixed red and black soils
Annual rainfall (mm)	1174
Potential evapotranspiration (mm)	1468
Length of growing period (LGP) / moisture availability period (days)	150 – 180

Soil and water conservation

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

Crop management

- **Varieties :** Local, Ganga – 5
- **Seed rate :** 18 – 20 kg/ha chandan safed
- **Planting pattern :** 60 x 20 cm
- **Nutrient management**
  - Composites: 80 kg N + 60 kg P_2O_5 + 20 kg K_2O/ha. Apply 50 % N as basal and 50 % in two splits at knee height and tasseling
  - Hybrids: 100 kg N + 60 kg P_2O_5 + 20 kg K_2O/ha. Apply 50 % N as basal and 50 % in two splits at knee height and tasseling

Suitable cropping system

- Maize + chickpea /safflower

Alternate farming systems

- **Agro – hortisystem:** Mango + Pea / Berseem (green fodder) / Wheat/ gram / soybean
- **Silvi – pastoral system :** Teak + sudan grass
- **Fodder/green biomass:** *Leucaena leucocephala, Albizzia amara, Dichrostachys cineria, Melia azadirach, Hardwickia binata, A.lebbeck*
- **Fruit:** Mango, Ber, Guava, Tamarind, Karonda
- **Medicinal & Aromatic Plants:** *Safed musli, Palma rosa, Withania somnifera, Papaver somniferum, Vetiveria zyzanoides*
- **Vegetables:** Brinjal, Chilli, Cowpea, Okra, Bottle gourd, Round melon.
- **Animal component:** Female Cattle, Male Cattle, Female Buffaloes, Goats

Contingent planning

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

State	District	Region
Madhya Pradesh	Shivapuri (Madhya Bharat Plateau)	High run off and High yield gap

Agro-geographic setting	Shivapure
Climate	Hot moist semi arid
Soils	Vertic soils – 100% Deep loamy and clayey mixed red and black soils
Annual rainfall (mm)	1179
Potential evapotranspiration (mm)	1498
Length of growing period (LGP) / moisture availability period (days)	120 – 150

Soil and water conservation

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

Crop management

- **Varieties :** Local, Ganga – 5
- **Seed rate :** 18 – 20 kg/ha chandan safed
- **Planting pattern :** 60 x 20 cm
- **Nutrient management**
  - Composites: 80 kg N + 60 kg P_2O_5 + 20 kg K_2O/ha. Apply 50 % N as basal and 50 % in two splits at knee height and tasseling
  - Hybrids: 100 kg N + 60 kg P_2O_5 + 20 kg K_2O/ha. Apply 50 % N as basal and 50 % in two splits at knee height and tasseling

Suitable cropping system

- Maize + chickpea /safflower

Alternate farming systems

- **Fodder/green biomass:** *Leucaena, Melia azadirachta, Dichro stachys cineraria, Albizzia amara, A.lebbeck, Hardwickia binata, A.nilotica*
- **Fruit:** *Emblica officinalis* (amla), Guava, Ber, Mango
- **Medicinal & Aromatic Plants:** *Rauvolfia serpentina, Vetivera zyzanoides, Palma rosa, Safed musli, Asvagandha*
- **Vegetables:** Bottle gourd, Brinjal, Tomato, Chillies, Brinjal, Cowpea, Okra
- **Animal component:** Female Cattle, Male Cattle, Female Buffaloes, Goat and Poultry

State	District	Region
Madhya Pradesh	Mandla (Satapura ranges)	High runoff and Medium yield gap

Agro-geographic setting	Mandla
Climate	Hot moist sub humid
Soils	Vertic soils – 85%; Vertisols – 15% Shallow to deep loamy to clayey mixed red and black soils
Annual rainfall (mm)	1425
Potential evapotranspiration (mm)	1304
Length of growing period (LGP) / moisture availability period (days)	180 – 210

Soil and water conservation

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

Crop management

- **Varieties :** Local, Ganga – 5
- **Seed rate :** 18 – 20 kg/ha chandan safed
- **Planting pattern :** 60 x 20 cm
- **Nutrient management**
  - Composites: 80 kg N + 60 kg P_2O_5 + 20 kg K_2O/ha. Apply 50 % N as basal and 50 % in two splits at knee height and tasseling
  - Hybrids: 100 kg N + 60 kg P_2O_5 + 20 kg K_2O/ha. Apply 50 % N as basal and 50 % in two splits at knee height and tasseling

Suitable cropping system

- Maize + chickpea /safflower

Alternate farming systems

- **Agro – hortisystem:** Mango + pea / Berseem (green fodder) / Wheat / chickpea / soybean
- **Silvi – pastoral system :** Teak + sudan grass
- **Fodder/green biomass:** *Leucaena leucocephala, Albizzia amara, Dichrostachys cineria, Melia azadirachta, Hardwickia binata, A.lebbeck*
- **Fruit:** Mango, Ber, Guava, Tamarind, Karonda
- **Medicinal & Aromatic Plants:** *Safed musli, Palma rosa, Withania somnifera, Papaver somniferum, Vetiveria zyzanoides*
- **Vegetables:** Brinjal, Chilli, Cowpea, Okra, Bottle gourd, round melon.
- **Animal component:** Female Cattle, Male Cattle, Female Buffaloes and Goats

Contingent planning

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

State	District	Region
Madhya Pradesh	Guna (North West) Shahdol (Eastern Madhya Pradesh, Madhya Pradesh)	High runoff and High yield gap

Agro-geographic setting	Guna
Climate	Hot dry moist semi arid
Soils	Vertic soils – 100%
	Deep loamy and clayey mixed red and black soils
	Medium and deep clayey black soils
	Shallow loamy black soils
Annual rainfall (mm)	1222
Potential evapotranspiration (mm)	1511
Length of growing period (LGP) / moisture availability period (days)	120 – 180

Soil and water conservation

- Broad bed furrow for soybean
- Gabion structures in waterways
- Graded border strips

- Sowing across the slope and ridging later
- Compartmental bunding
- Mulching

Crop management

- **Varieties :** Local, Ganga – 5
- **Seed rate :** 18 – 20 kg/ha
- **Planting pattern :** 60 x 20 cm
- **Nutrient management**
  - Composites: 80 kg N + 60 kg P_2O_5 + 20 kg K_2O/ha. Apply 50 % N as basal and 50 % in two splits at knee height and tasseling
  - Hybrids: 100 kg N + 60 kg P_2O_5 + 20 kg K_2O/ha. Apply 50 % N as basal and 50 % in two splits at knee height and tasseling

Suitable cropping system

- Maize + chickpea /safflower

Alternate farming systems

- **Fodder/green biomass:** *Dichrostachys cineria, Albizzia amara, Faidherbia albida, Hardwickia binata, Cassia, Leucaena leucocephala, Albizzia lebbeck*
- **Fruit:** Ber, Pomegranate, Mango, Fig, Tamarind
- **Medicinal & Aromatic Plants:** *Withamnia somnifera, Rauvolfia serpentina, Vetiveria zyzanoides, Palma rosa, Liquorice.*
- **Vegetables:** Chillies, Okra, Watermelon, Cowpea, Cluster bean, Amaranthus, round melon.
- **Animal Component:** Female and male Cattle, Female Buffaloes, Goat, Poultry

Shahdol (Eastern Madhya Pradesh, Madhya Pradesh)

Agro-geographic setting	Shahdol	High run off and High yield gap
Climate	Hot dry sub humid	
Soils	Vertic soils – 60%; Ustalf/Ustolls – 40%	
	Deep loamy to clayey mixed red and black soils	
Annual rainfall (mm)	1335	
Potential evapotranspiration (mm)	1342	
Length of growing period (LGP) / moisture availability period (days)	150 – 180	

Soil and water conservation

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

Crop management

- **Varieties :** Local, Ganga – 5
- **Seed rate :** 18 – 20 kg/ha chandan safed
- **Planting pattern** : 60 x 20 cm
- **Nutrient management**
  - Composites: 80 kg N + 60 kg P_2O_5 + 20 kg K_2O/ha. Apply 50 % N as basal and 50 % in two splits at knee height and tasseling
  - Hybrids: 100 kg N + 60 kg P_2O_5 + 20 kg K_2O/ha. Apply 50 % N as basal and 50 % in two splits at knee height and tasseling

Suitable cropping system

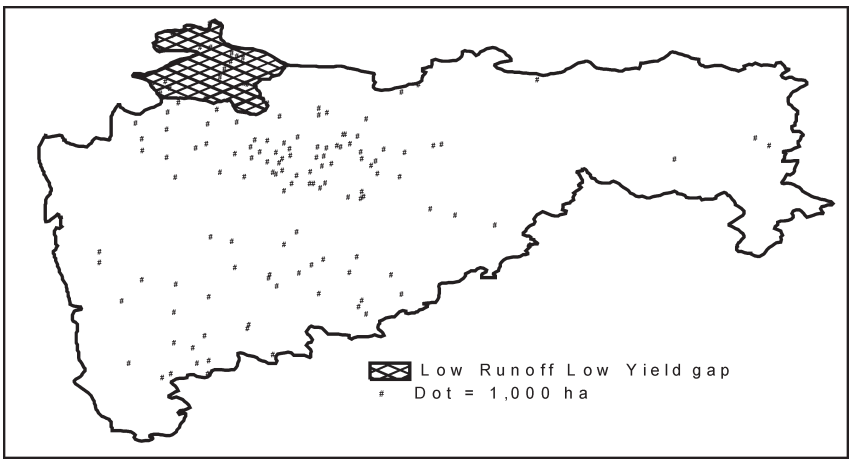
- Maize + chickpea /safflower

Alternate farming systems

- **Fodder/green biomass:** *Leucaena leucocephala, Albizzia amara, Dichrostachys cineria, Melia azadirachta, Hardwickia binata, A.lebbeck*
- **Fruit:** Mango, Ber, Guava, Tamarind, Karonda
- **Medicinal & Aromatic Plants:** *Safed musli, Palma rosa, Withania somnifera, Papaver somniferum, Vetiveria zyzanoides*
- **Vegetables:** Brinjal, Chilli, Cowpea, Okra, Bottle gourd, round melon.
- **Animal Component:** Female Cattle, Male Cattle, Female Buffaloes, and Goats

MAHARASHTRA

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



State	District	Region
Maharashtra	Dhule (Western Maharashtra plateau)	Low runoff and Low yield gap

Agro-geographic setting	Dhule
Climate	Hot semi arid
Soils	Vertic soils – 65 %; Vertisols – 35 %
	Shallow and Medium loamy
	Medium and deep clayey black soils
Annual rainfall (mm)	738
Potential evapotranspiration (mm)	1713
Length of growing period (LGP) / moisture availability period (days)	120 – 150

Soil and water conservation

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

Crop management

- **Varieties** : DHM-1O1, Ganga
- **Seed rate**: 18 kg/ha
- **Planting pattern**: 60 x 25 cm
- **Nutrient management :** 75 kg N + 40 kg P_2O_5 /ha.

Tool/Implement	Cost	Operation carried
1) Tractor multi crop planter	Rs.22800/-	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.
2) Bullock drawn Jyoti Planter.	Rs.7500/-	The field trials were conducted and the machine is recommended for sowing the crops of dryland region.
3) Weeders developed by Maharashtra Agro Industries Development Corporation Ltd. (MAIDC)	Rs.410/-	These weeders were tested on farmer's field and identified for weeding and interculturing in row crops.
4) Tractor drawn		Tested on farmers' field for ploughing and identified for ploughing
a) Single bottom reversible plough.	Rs.18500/-	operations in dryland region as the field operation was
b) Double bottom reversible plough.	Rs.23600/-	effective and economical.
5) Bund former	Rs.1050/-	Bund formers were tested and found suitable for compartmental bunding.
6) Baliram plough	Rs.2500/-	Identified for moisture conservation practices like ridges and furrows and compartmental bunding.
7) Kopergaon bullock drawn two-bowl seed drill.	Rs.9000/-	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.

Suitable cropping systems

- Maize -safflower

Farm Implements / tools

Alternate farming systems

- **Silvipasture:** *Leucaena* + Marvel –8
- **Alley cropping:** Ber (20 m alleys) + Pearlmillet + Pigeonpea for shallow soils
- **Fodder:** Maize (African Tall), Oats (Kent), Stylo hamata
- **Fodder/ green biomass:** *Dalbergia sissoo, Albizzia lebbeck, Anogeissus latfolia, Sesbania, Stylo Marvel – 8 grass*
- **Fruit:** Ber, Custard apple, Pomegranate, amla+*kharif* spreadingcrops
- **Medicinal/ Aromatic Plants:** *Catharanthus roseus, Palma rosa, Vetiveria zyzanoides, Rose, Geranium.*
- **Vegetables:** Onion, Tomato, Okra, Cowpea, Cluster bean, Drumstick
- **Animal component:**
  - Cow breeds: Gir, Jersey
  - Poultry: White Leghorn
  - Rams
  - Male/ female cattle, female buffaloes, sheep, goat

Alternate land use system

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

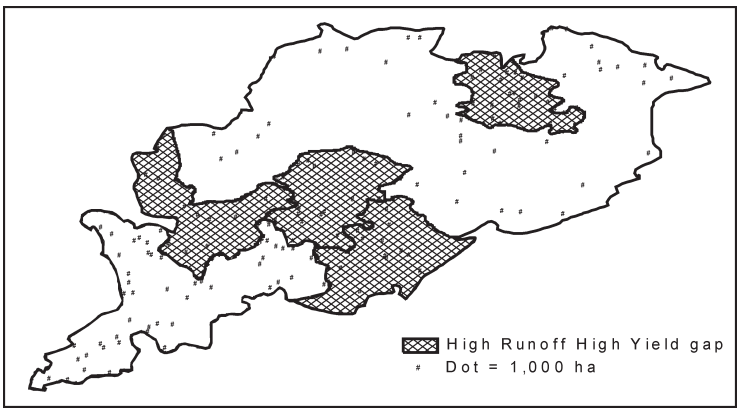
Contingent Planning

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

2nd Fortnight of June	All *kharif* crops
1st 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)
2nd Fortnight of July	Sunflower, Pigeonpea, Horsegram, Setaria, Castor, Pearlmillet (ergot resistant), Intercropping of Sunflower + pigeonpea (2:1)
1st Fortnight of August	Sunflower, Pigeonpea, Castor, Horsegram, Sunflower + pigeonpea (2:1)
2nd Fortnight of August	Sunflower, Pigeonpea, Castor, Sunflower + pigeonpea (2:1)
1st Fortnight of September	Sorghum for fodder
2nd Fortnight of September	*Rabi s*orghum, Safflower, Sunflower
1st Fortnight of October	Rabi sorghum, Safflower, Chickpea, Sunflower
2nd Fortnight of October	Chickpea, Sunflower, *Rabi* sorghum.
1st Fortnight of November	Chickpea, Sunflower.

ORISSA

In Orissa there are four districts viz. Koraput, Kalahandi, Ganjam and Phulbani under high runoff and high yield gap region.



State	District	Region
Orissa	Koraput (Southern Orissa) Kalahandi (South West Orissa) Ganjam and Phulbani (Eastern ghats)	High runoff and High yield gap

Agro-geographic setting	Koraput	Kalahandi	Ganjam	Phulbani
Climate	Hot moist sub humid	Hot moist sub humid	Hot (moist/ dry) sub humid Hot dry sub humid	Hot moist sub humid
Soils	Loamy Alfisols – 80%; Sandy Alfisol – 20% Deep laomy red and lateritic soils	Ustalf/Ustolls – 70%; Loamy Alfisols – 30% Deep laomy red and lateritic soils	Orthids – 40%; Sandy Alfisol – 60% Medium to deep loamy red and lateritic Deep loamy to clayey coastal and deltaic alluvium derived soils	Loamy Alfisol – 50%; Ustalf/Ustolls – 50% Deep loamy red and lateritic soils
Annual rainfall (mm)	1671	1511	1311	1425
Potential evapotranspiration (mm)	1630	1524	1662	1642
Length of growing period (LGP) / moisture availability period (days)	180 – 210	180 – 210	180 – 210	180 – 210

Soil and water conservation

- Bench terracing
- Compartmental bunding
- Graded border strips

- Sowing across the slope and ridging later
- Insitu conservation of soil moisture

Crop management

- **Varieties :** Navjot, DHM - 103
- **Seed rate:** 15 kg/ha
- **Planting Pattern**: 6o x 30 cm
- **Nutrient management**
  - 80 kg N + 40 kg P_2O_5 + 40 kg K_2O/ha. P and K as basal. 25 % N as basal, 50% N at 21 days after sowing and 25% N at 6-7 weeks after germination

Suitable cropping systems

Uplands :

- Maize (Navjot) – toria (PT 303/M-27)
- Maize (Navjot) + cowpea (SGL-1, Arka Kamal)- rapeseed mustard (PT-303, M-27).
- Maize (Navjot) + pigeonpea (T-21, R-60):

  Short duration maize and long duration pigeonpea are grown in uniform alternate rows in 1:1 row ratio or paired rows of maize are alternated with paired rows of pigeonpea in 2:2 row ratio. Maize is harvested before canopy development starts in pigeonpea. In this system, 100% population of each of the sole crop is maintained.
- Maize (Navjot) + cowpea (SEB-2):

  Two rows of low-trailing cowpea are grown between paired rows of maize with set specification 30-90-30cm. Green pods of cowpea are harvested during 60-70 days after germination.
- Maize (Navjot) + cowpea (SGL-1, Arka Kamal):

  Maize and non-trailing cowpea is grown in 30 cm apart uniform rows alternately. Green pods of cowpea are harvested within 50-60 days after germination. Green biomass of cowpea is used as mulch-cum-manure between rows of maize. Cowpea may be harvested for grain purpose at 70 days after germination
- Maize (Navjot) + Runner bean (local) :

  Runner bean is planted in basins prepared with 90 cm spacing. In each basin, 2 runner bean plants are maintained. Two rows of maize are planted in 90 cm spacing between 2 basins of runner bean. Maize acts as live-staking material for runner bean.

- **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

- Hand Hoe

Alternate Farming systems

- **Non – arable wastelands :**
  - Tree farming (*Sal, Teak*)
  - Silvi-pastoral *(Shisham/Subabul/Gambar* + Stylo/Cenchrus/mixure)
- **Arable wastelands :**
- **Agri-horticulture :**
  - Fruit crops (mango/citrus/sapota/pomogranate/custard apple/aonla/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 : Subabul (4 m interval) + groundnut/sesame/cowpea (grain)
  - *Leucaena* + turmeric/ginger
- **Fodder/green biomass:** *P.pinnata, Albizzia sps, Cassia siamea, Grevellea robusta, D. sissoo, Azadirachta indica*
- **Fruit:** Mango, Jackfruit, Guava, Lime
- **Medicinal & Aromatic Plants:** *Vetiveria zyzanoides, Cymbopogan flexuosus, Palma rosa, Solanum viarum, Cinnamon, Citronella java*
- **Vegetables:** Bottle gourd, Brinjal, Ridge gourd, Watermelon, Long melon, Bitter gourd, Tomato
- **Animal Component:** Female cattle, Male cattle, Goat

Contingent crop planning

- **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 and Padmini

Late duration :

- Utkalaprava, Gayatri, Savitri, Prachi, Ramachani , Mahanadi and Indrabati

- **Fingermillet :** Dibyasinha, Nilachala, Bhairabi and Subhra
- **Maize :** Navjot, Vijaya, DHM-103 and Ganga-5
- **Greengram :** PDM-54, K- 851, Dhauli and TARM-2
- **Blackgram :** Pant U-30 , T-9 and Sarala
- **Pigeonpea :** UPAS-120 , R-60, T-21 and S-5
- **Cowpea :** SEB-2, SGL-1, Arka Kamal
- **Horsegram :** Urmi and Local
- **Groundnut :** Smruti (OG 52-1), JL-24, ICGS-11 and AK 12-24
- **Castor :** Aruna, DCH-177 and DCH-30
- **Rapeseed & Mustard :** PT- 303, M-27, Parvati and Anuradha
- **Sesame :** Vinayak, Uma, Usha and Prachi
- **Niger :** Deomali (GA-10), IGP-76 and Phulbani Local
- **Linseed :** Kiran, Laxmi-27, Pusa-3, Padmini
- **Sunflower :** Morden
- **Cotton :** MCU-5, NHH-44, Somanath, Savita and Bunny
- **Ginger :** Vardhan, China and Nadia
- **Turmeric :** Sudarsan, Suguna, Subarna and Rajendra Horti-5.
- **Yam :** Hatikhoja, Srikirti, Srirupa
- **ABERRANT WEATHER:**
  - **Upland**
  - **Early season drought/Delay in onset of monsoon:**
    - When upland rice is completely damaged, the crop may be cut down for supplying straw to the cattle. Non-paddy crops viz. fingermillet (Subhra, Bhai*rabi*, Dibyasingha and Godavari), Greengram (K 851, PDM-11 and PDM-54), blackgram (T-9, Sarala and Pant U-30), Cowpea (SEB-2, SGL-1, Arka Kamal), horsegram (Urmi), ricebean (RBL 6), sesame (Usha, Uma) and castor (Aruna, DCS-9), niger (IGP-76 and Deomali) or sunflower (Morden) should be taken. Drought tolerant varieties of crop(s)/cropping system(s) should be taken up. The crop /variety should be selected basing on available effective growing season.
  - **Mid-season drought:**
    - Weeding and hoeing should be done in all the crops except groundnut in flowering stage. Weeds in groundnut should be cut or uprooted not to interfere in pegging and pod formation. Hoeing creates a soil mulch and decreases moisture loss from the soil. Uprooted weeds should be used as mulch between crop rows.
    - Foliar spraying of 2% urea in upland rice and fingermillet gives good results. For this, 200 g of urea is mixed with 10 litre of water and sprayed on the foliage of the crop. Plant protection chemicals

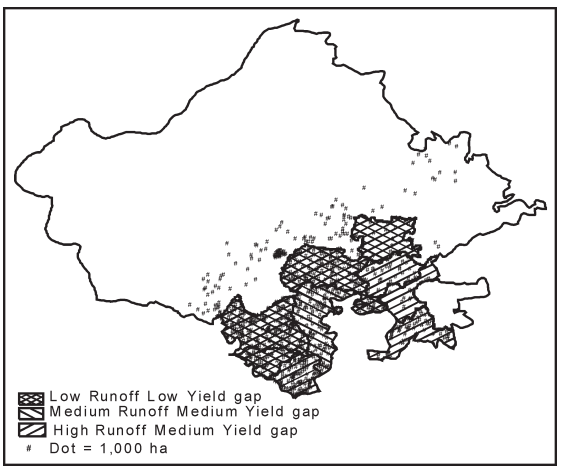
may be mixed with urea solution to minimize the cost of spraying. In a single spray 10kg/ha of urea is applied through 500 litre solution.

- Excess plants in the crop row should be thinned to reduce moisture loss from the soil.
- Use of tender twigs of *Leucaena, Glyricidia sepium, Cassia siamea* and *Mimosa invisa* and plants of sunhemp as mulch-cum-manure reduces evaporation loss from the soil.
- Spraying of planofix 10 ppm at 45 days after sowing and 20 ppm at flowering in cotton to prevent fruit drop.

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

RAJASTHAN

In Rajasthan there are four districts viz. Bhilwara, Udaipur, Dungarpur and Tonk under low runoff and low yield gap region, two districts viz. Chittorgarh and Kota under medium runoff and medium yield gap region and three districts viz. Banswara, Bundi and Jalawar under medium runoff and high yield gap region. The trends in area, production and productivity of maize in Rajasthan (1980 - 2005) are shown in Fig. 4.



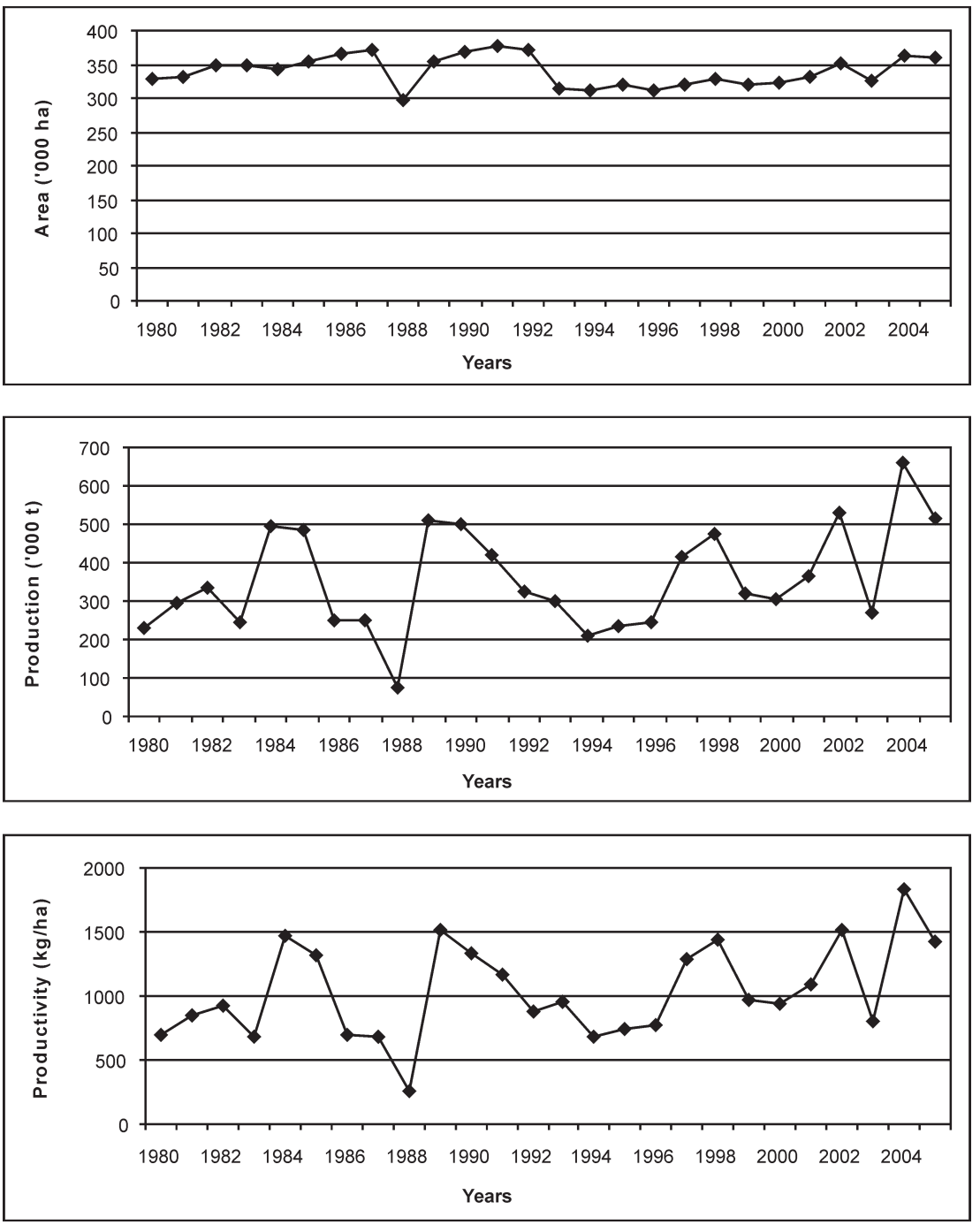
State	District	Region
Rajasthan	Bhilwara (Eastern Rajasthan Uplands) Udaipur and Durgapur (Southern Rajasthan) Tonk (Central East Rajasthan)	Low runoff and Low yield gap

Agro-geographic setting	Bhilwara	Udaipur	Dungarpur	Tonk
Climate	Hot dry semi arid	Hot dry semi arid	Hot dry semi arid	Hot dry semi arid
Soils	Vertic soils – 100% Deep loamy grey brown and alluvium - derived soils	Pssaments – 30 %; Vertic soils – 70 % Deep loamy grey brown and alluvium - derived soils	Vertic soils – 100% Deep loamy grey brown and alluvium - derived soil	Inceptisols – 100% Deep loamy grey brown and alluvium - derived soils
Annual rainfall (mm)	658	661	715	703
Potential evapotranspiration (mm)	1559	1380	1503	1597
Length of growing period (LGP) / moisture availability period (days)	90 – 120	90 - 120	90 – 120	90 – 120

Soil and water conservation

- More emphasis on *in situ* water conservation
- Increasing soil infiltration capacity and reducing soil crusting problem
- Contour furrowing
- Absorption terracing
- Contour trenches

Fig. 4. Trends in Area, Production and Productivity of Maize in Rajasthan (1980-2005)



- Inter-row water harvesting
- Inter-plot water harvesting of 1:1 cropped to un-cropped land
- Dead furrows at 3.6 m interval

Crop management

- **Varieties :** PEHM-2, Navjot, Surya
- **Seed rate**: 25 kg/ha
- **Planting Pattern:** 60 cm rows
- **Nutrient management**
  - 50 kg N + 30 kg P_2O_5/ ha and apply N in 2 splits ½ as basal and ½ at knee high stage
- **Weed control:** Apply Atrazine (0.5 kg/ha) followed by one interculture
- **Some other important practices**
  - Sowing of maize with compartmental bunding helps for *in-situ* soil moisture conservation
  - Sowing of maize in ridges is good practice during drought as well as excess rainfall

Suitable cropping systems

- Maize-rapeseed mustard on heavy soils with good rainfall
- Maize + blackgram (2:2 row ratio in paired planting 37 cm)
- Maize + pigeonpea (alternate rows at 30 cm)
- Maize + castor (1: 1 row ratio)

Farm Implements / tools

- Arjia pora
- Dryland weeder

Alternate farming systems

- **Trees on crop lands :**
  - Marginal lands :
  - Silviculture: *Acacia tortilis*
  - LCC III : Alley cropping (Jatropha spp + Greengram)
  - LCC IV : Silvipastoral system: *Prosopis cinerasia* + *Cenchrus sp*
  - Horti – Pastoral system: Ber + C*enchrus setigerus*
- **Fodder/green biomass:** *Alianthus excelsa, A.lebbeck, D.sissoo, A.indica, P.cineraria, Dichrostachys*
- **Fruit:** Ber, Date palm, Jamun,Fig, Phalsa, Karonda
- **Medicinal & Aromatic Plants:** *Plantago ovata, Cassia angustifolia, Safed musli, Papaver somniferum*
- **Vegetables:** Clusterbean, Cowpea, Amaranth, round melon, Long melon
- **Animal component:** Female Cattle, Male Cattle, Female Buffaloes, Sheep and Goats

Contingent planning

- Good and normal rainfall
  - Grow large areas under improved varieties of cereals, pulses and oilseeds during *kharif* on heavy soils, conserve soil moisture during *kharif* and take 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 / pigeon pea, groundnut + sesame is recommended.
- Early withdrawal of monsoon:
  - Conserve the soil moisture received during last season and grow early *rabi* crops like rapeseed mustard, chickpea , safflower etc.

State	District	Region
Rajasthan	Chittorgarh and Kota (South East Rajasthan)	Medium runoff and Medium yield gap

Agro-geographic setting	Chittorgarh	Kota
Climate	Hot dry moist semi arid	Hot moist semi arid
Soils	Vertic soils – 100% Deep loamy grey brown and alluvium - derived soils Deep clayey black soils Shallow black soils	Vertic soils – 100% Deep clayey black soils Shallow black soils
Annual rainfall (mm)	885	842
Potential evapotranspiration (mm)	1556	1523
Length of growing period (LGP) / moisture availability period (days)	90 – 150	120 – 150

Soil and water conservation

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

Crop management

- **Varieties :** PEHM-2, Navjot, Surya

- **Seed rate**: 25 kg/ha
- **Planting Pattern**: 60 cm rows
- **Nutrient management**
  - 50 kg N + 30 kg P_2O_5/ ha and apply N in 2 splits ½ as basal and ½ at knee high stage
- **Weed control:** Apply Atrazine (0.5 kg/ha) followed by one interculture

Some other important practices

- Sowing of maize with compartmental bunding helps for in-situ soil moisture conservation
- Sowing of maize in ridges is good practice during drought as well as excess rainfall

Suitable cropping systems

- Maize-rapeseed mustard- on heavy soils with good rainfall
- Maize + blackgram (2:2 row ratio in paired planting 37 cm)
- Maize + pigeonpea (alternate rows at 30 cm)
- Maize + castor (1:1 row ratio)

Farm Implements / tools

- Arjia pora
- Dryland weeder

Alternate farming systems

- **Trees on crop lands**
  - Marginal lands :
  - Silviculture: *Acacia tortilis*
  - LCC III : Alley cropping (Jatropha spp + Greengram)
  - LCC IV : Silvipastoral system: *Prosopis cineraria* + *Cenchrus sp*
  - Horti – Pastoral system: Ber + *Cenchrus setigerus*
- **Fodder/green biomass:** *Alianthus excelsa, A.lebbeck, D.sissoo, A.indica, P.cineraria, Dichrostachys*
- **Fruit:** Ber, Date palm, Jamun, Fig, Phalsa, Karonda
- **Medicinal & Aromatic Plants:** *Plantago ovata, Cassia angustifolia, Safed musli, Papaver somniferum*
- **Vegetables:** Clusterbean, Cowpea, Amaranthus, round melon, Long melon
- **Animal component:** Female Cattle, Male Cattle, Female Buffaloes, Sheep and Goats

Contingent planning

- Good and normal rainfall
  - Grow large areas under improved varieties of cereals, pulses and oilseeds during *kharif* on heavy soils, conserve soil moisture during *kharif* and take 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 / pigeon pea, groundnut + sesame is recommended
- Early withdrawal of monsoon:
  - Conserve the soil moisture received during last season and grow early *rabi* crops like rapeseed mustard, chickpea, safflower etc.

State	District	Region
Rajasthan	Banswara, Bundi and Jhalawar(South Rajasthan)	Medium runoff and High yield gap

Agro-geographic setting	Banswara	Bundi	Jhalawar
Climate	Hot moist semi arid	hot dry semi arid hot moist semi arid	Hot moist semi arid
Soils	Vertic soils – 100% Deep clayey black soils Shallow black soils	Vertic soils – 100% Deep loamy grey brown and alluvium - derived soils Deep clayey black soils Shallow black soils	Vertic soils – 100% Deep clayey black soils Shallow black soils
Annual rainfall (mm)	938	768	1024
Potential evapotranspiration (mm)	1512	1554	1557
Length of growing period (LGP) / moisture availability period (days)	120 – 150	90 – 150	120 – 150

Soil and water conservation

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

Crop management

- **Varieties :** PEHM-2, Navjot, Surya
- **Seed rate:** 25 kg/ha
- **Planting Pattern**: 60 cm rows
- **Nutrient management**
  - 50 kg N + 30 kg P_2O_5/ ha and apply N in 2 splits ½ as basal and ½ at knee high stage
- **Weed control:** Apply Atrazine (0.5 kg/ha) followed by one interculture

- **Some other important practices**
  - Sowing of maize with compartmental bunding helps for *in-situ* soil moisture conservation
  - Sowing of maize in ridges is good practice during drought as well as excess rainfall

Suitable cropping systems

- Maize- rapeseed mustard- on heavy soils Maize + blackgram (2:2 row ratio in paired planting 37 cm)
- Maize + pigeonpea (alternate rows at 30 cm)
- Maize + castor (1:1)

Farm Implements / tools

- Arjia pora
- Dryland weeder

Alternate farming systems

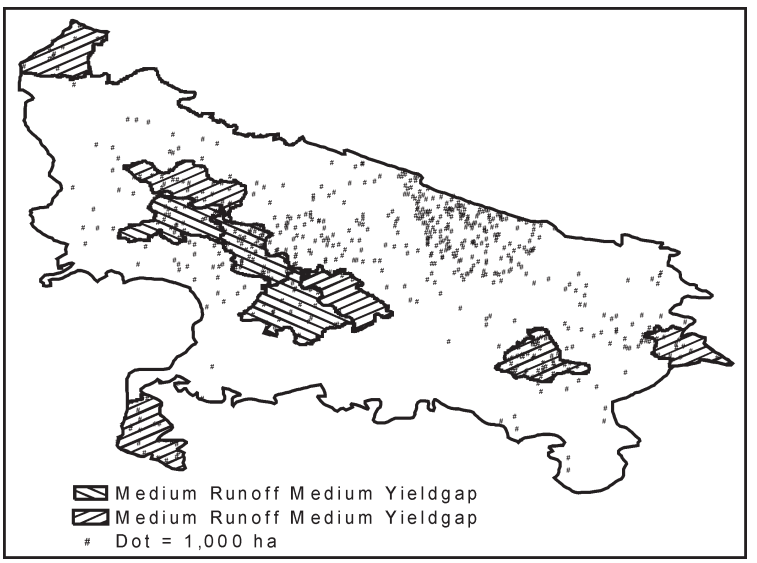
- **Trees on crop lands :**
  - Marginal lands :
  - Silviculture: *Acacia tortilis*
  - LCC III : Alley cropping (Jatropha spp + Greengram)
  - LCC IV : Silvipastoral system: *Prosopis cineraria* + *Cenchrus sp*
  - Horti – Pastoral system: Ber + C*enchrus setigerus*
- **Fodder/green biomass:** *Alianthus excelsa, A.lebbeck, D.sissoo, A.indica, P.cineraria, Dichrostachys*
- **Fruit:** Ber, Date palm, Jamun,Fig, Phalsa, Karonda
- **Medicinal & Aromatic Plants:** *Plantago ovata, Cassia angustifolia, Safed musli, Papaver somniferum*
- **Vegetables:** Clusterbean, Cowpea, Amaranth, Round melon, Long melon
- **Animal component:** Female and male Cattle, Female Buffaloes, Sheep, Goats

Contingent planning

- Good and normal rainfall
  - Grow large areas under improved varieties of cereals, pulses and oilseeds during *kharif* on heavy soils, conserve soil moisture during *kharif* and take 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 / pigeon pea, 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 three districts viz. Kanpur, Farukkabad and Etah under medium runoff and medium yield gap region and six districts viz. Unnao, Lalitpur, Baduan, Jaunpur, Ballia and Saharahpur under medium runoff and high yield gap region.



State	District	Region
Uttar Pradesh	Kanpur (Ganga – Yamuna Doab)	Medium runoff and Medium yield gap
	Farukkabad and Etah (Ganga – Yamuna Doab)	

Agro-geographic setting	Kanpur (rural)
Climate	Hot moist semi arid
Soils	Inceptisols – 100%
	Deep loamy alluvium - derived soils
Annual rainfall (mm)	882
Potential evapotranspiration (mm)	1661
Length of growing period (LGP) / moisture availability period (days)	120 – 150

Soil and water conservation

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

- Deep ploughing during summer followed by two cultivators
- Indigenous Water harvesting structures

Crop management

- **Varieties :** Ganga safed –2, Kanchan, Jankpuri
- **Seed rate:** 15 kg/ha
- **Planting pattern**

Farm Implements / tools

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

Alternate farming systems

- **Agri-horti system:** Guava + maize
- **Fodder/green biomass:** *Leucaena, D. sissoo, Azadiracta indica, Syzygium cumini, Sesbania, Pongamia, Cassia siamea*
- **Fruit:** Mango, Guava, Amla, Ber, Phalsa, Bael, Jamun.
- **Medicinal & Aromatic Plants***: Papaver somniferum Palmorosa, Vetiveria zyzanoides, Cymbopogan flexuosus*
- **Vegetables:** Tomato, Brinjal, Okra, Chilli, Amaranthus
- **Animal Component:** Female and male Cattle, Female Buffaloes, Sheep, Goat and Poultry

Agro-geographic setting	Farukkabad	Etah
Climate	Hot moist semi arid	Hot semi arid
Soils	Inceptisols – 100% Deep loamy alluvium - derived soils	Inceptisols – 100% Deep loamy alluvium - derived soils
Annual rainfall (mm)	871	741
Potential evapotranspiration (mm)	1488	1454
Length of growing period (LGP) / moisture availability period (days)	120 – 150	90 – 120

Soil and water conservation

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

- Deep tillage during summer and making compartmental bunding after seedlings emergence.
- Criss-cross ploughing by country plough after each effective rainfall.
- 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 the adverse effect of late season drought.

Crop management

- **Varieties:** Ganga safed
- **Planting pattern:** 60 x 20 cm

Farm Implements / tools

- Dryland weeder is quite effective and economic in controlling the weeds in both seasons.

Alternate farming systems

- **Agro hortisystem:** Ber + greengram/ clusterbean/ cowpea for grain purpose
- Ber + pearlmillet (fodder)
- **Fodder/green biomass**: *A.indica, Leucaena, A. lebbeck, H. binata, Pongamia, C. siamea, Bauhinia*
- **Fruit:** Mango, gauva, Amla, Phalsa, Jamun, Karonda
- **Medicinal & Aromatic Plants***: Papaver somniferum, Palma rosa, Cymbopogan flexuosus, Vetiveria zyzanoides*
- **Vegetables:** Tomato, Chillies, Brinjal, Okra, Bottle gourd, Amaranthus, Cowpea
- **Animal component:** Female Cattle, Female Buffaloes, Goat and Poultry

Contingent planning

- ***Kharif***
  - Under normal rainfall :
    - Pearlmillet (Proagro-9402), pigeonpea (UPAS-120), greengram (K-851), clusterbean (RGC-197)
  - As the monsoon progresses
  - 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) , and Taramira (TMH-1) and safflower in the order.

State	District	Region
Uttar Pradesh	Unnao (Ganga – Yamuna Doab) Lalitpur (Bhulkhand Uplands, Uttar Pradesh) Badaun (Ganga – Yamuna Doab Jaunpur and Ballia (Ganga – Yamuna Doab) Saharanpur	Medium runoff and High yield gap

Agro-geographic setting	Unnao
Climate	Hot moist semi arid
Soils	Inceptisols – 100% Deep loamy alluvium - derived soils
Annual rainfall (mm)	946
Potential evapotranspiration (mm)	1567
Length of growing period (LGP) / moisture availability period (days)	120 – 150

Soil and water conservation

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

Crop management

- **Varieties :** Hy. Ganga –5, Hy. Ganga safed 2, Jaunpuri
- **Nutrient management :** 80 kg N + 40 kg P_2O_5 + 30 kg K_2O

Farm Implements / tools

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

Alternate farming systems

- **Fodder/green biomass:** *Leucaena, D. sissoo, Azadiracta indica, Syzygium cumini, Sesbania, Pongamia, Cassia siamea*
- **Fruit:** Mango, Guava, Amla, Ber, Phalsa, Bael, Jamun.
- **Medicinal & Aromatic Plants:** *Papaver somniferum Palmorosa, Vetiveria zyzanoides, Cymbopogan flexuosus*
- **Vegetables:** Tomato, Brinjal, Okra, Chilli, Amaran-thes
- **Animal Component:** Female Cattle, Female Buffaloes, Male Cattle, Sheep, Goat and Poultry

Agro-geographic setting	Lalitpur
Climate	Hot moist semi arid
Soils	Inceptisols – 100% Deep loamy and clayey mixed red and black soils
Annual rainfall (mm)	804
Potential evapotranspiration (mm)	1489
Length of growing period (LGP) / moisture availability period (days)	120 – 150

Soil and water conservation

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

Crop management

- **Varieties :** Hy. Ganga –5, Hy. Ganga safed - 2, Jaunpuri
- **Nutrient management :** 80 kg N + 40 kg P_2O_5 + 30 kg K_2O

Alternate farming systems

- **Fodder/green biomass***: Leucaena, Melia azadirachta, Dichro stachys cineraria, Albizzia amara, A.lebbeck, Hardwickia binata, A.nilotica*
- **Fruit:** *Emblica officinalis* (amla), Guava, Ber, Mango
- **Medicinal & Aromatic Plants:** *Rauvolfia serpentina, Vetiveria zyzanoides, Palma rosa, Safed musli, Asvagandha*
- **Vegetables:** Bottle gourd, Brinjal, Tomato, Chillies, Brinjal, Cowpea, Okra
- **Animal component:** Female Cattle, Male Cattle, Female Buffaloes, Goat, and Poultry

Agro-geographic setting	Badaun
Climate	Hot moist semi arid
Soils	Inceptisols – 100% Deep loamy alluvium - derived soils
Annual rainfall (mm)	891
Potential evapotranspiration (mm)	1439
Length of growing period (LGP) / moisture availability period (days)	120 – 150

Soil and water conservation

- Compartmental bunding after seedling emergence
- Contour farming
- Graded border strips

- Sowing across the slope and ridging later
- To mitigate early season drought, one extra inter cultivation along with straw mulch @ 5 t/ha is effective.
- One protective irrigation is only solution to control late season drought effect during summer.
- Deep tillage during summer and making compartmental bunding after seedlings emergence.
- Criss-cross ploughing by country plough after each effective rainfall.
- 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 the adverse effect of late season drought.

Crop management

- **Varieties :** Hy. Ganga –5, Hy. Ganga safed - 2, Jaunpuri
- **Nutrient management :** 80 kg N + 40 kg P_2O_5 + 30 kg K_2O

Farm Implements / tools

- Dryland weeder is quite effective and economic in controlling the weeds in both seasons.

Alternate farming systems

- **Agro hortisystem:** Ber + greengram/ clusterbean/ cowpea for grain purpose

  Ber + pearlmillet (fodder)
- **Fodder/green biomass**: *A.indica, Leucaena, A. lebbeck, H. binata, Pongamia, C. siamea, Bauhinia*
- **Fruit:** Mango, gauva, Amla, Phalsa, Jamun, Caronda
- **Medicinal & Aromatic Plants:** *Papaver somniferum, Palma rosa, Cymbopogan flexuosus, Vetiveria zyzanoides*
- **Vegetables:** Tomato, Chillies, Brinjal, Okra , Bottle gourd, Amaranth and Cowpea.
- **Animal Component:** Female Cattle, Female Buffaloes, Goat, and Poultry

Contingent planning

- ***Kharif***
  - Under normal rainfall :
    - Pearlmillet (Proagro-9402), pigeonpea (UPAS-120), greengram (K-851), clusterbean (RGC-197)
  - As the monsoon progresses
  - 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:***
  - Mustard (Pusa Jaikisan), Barley, Ratna, Chickpea (K-850), lentil (L-9-12) , and Taramira (TMH-1) and safflower in the order.

Agro-geographic setting	Jaunpur	Ballia
Climate	Hot moist semi arid	hot dry sub humid
		hot/ moist sub humid
Soils	Inceptisols – 100%	Inceptisols – 100%
	Deep loamy alluvium - deveried soils	Deep loamy aluvium derived soils
		Deep, Loamy alluvium - derived soils
Annual rainfall (mm)	1079	1085
Potential evapotranspiration (mm)	1538	1492
Length of growing period (LGP) / moisture availability period (days)	120 – 150	150 – 210

Soil and water conservation

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

Crop management

- **Varieties :** Ganga safed-2 (suitable for sequence and inter cropping system), Kanchan, Jaunpuri
- **Seed rate:** 25 kg/ha
- **Planting Pattern:** 60 x 20 cm

Suitable cropping systems

- Maize – lentil
- Maize + mustard
- Maize + blackgram (1: 3)
- Maize + okra
- For fodder:
- Maize + cowpea-oats

Farm Implements / tools

Tool implement	Cost/unit	Operations
Bullock drawn Malviya multi – farming machine	Rs. 2350/=	1. For field preparation 2. For seeding dryland crops and fertilizing through mechanical metering device 3. For inter cultivation between two plant rows (particularly *Kharif* season crop)
Dryland weeder (modified from of weeder supplied by T.A.U)	Rs.70/-	For weed control between plant rows of rainfed crops

Alternate Farming systems

- **Agrohortisystem:** Guava + pigeonpea
- **Fodder/green biomass:** *Luecaena leucocephala. Azadirachta indica, Albizzia lebbeck, Bauhinia purpurea, A. procera, B.monosperma, A.amara, D.sissoo*
- **Fruit:** Guava, Amla, Ber, Mango Bael, Jamun
- **Medicinal & Aromatic Plants:** *Papaver somniferum, Cymbopogan flexuosus, P. rosalea, Palma rosa, Vetiveria zyzanoides*
- **Vegetables:** Bottle gourd, Brinjal, Chillies, Cluster bean, Cowpea, round melon
- **Animal component:** Female Cattle, Female Buffaloes, Male Cattle, Sheep, Goat and Poultry

Contingent planning

- ***Normal season:***
  - Recommended crop and varieties along with other cultural practices should be followed as under:
- ***Kharif***
  - Rice : NDR-97, NDR-118, Govind, Vandana
  - Maize : Ganga safed-2, Knachan, Jaunpuri
  - Pearlmillet : BJ-104, Pusa-23, Pusa-322
  - Blackgram : T-9, Pant U-19, Pant U-35
  - Greemgram : Jyoti Jagriti, Janpriya,Pant moong-1,Narendra moong-1
  - Sesam : T-4, T-12, Gujrat til-1.
  - Pigeonpea : Bahar, NA-1, T-21
- ***Rabi***
  - Lentil : Pant L-406, PantL-639, L-4076, K-75
  - Wheat : HUW-533, K-8027, C-306
  - Barley : DL-3, Jyoti, K-125
  - 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 & low lands. Uplands should be considered for Pigeonpea base intercrop. If rains are delayed beyond the period but start somewhere in the first to second week of August and growing season is reduced to 60-70 days, then the cultivation of hybrid pearlmillet (BJ-560, BJ-104), blackgram (T-9), greengram (Jagriti, Jyoti) should be taken up. Pulse base intercropping is also recommended. Yet another alternative could be to harvest a fodder of either 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, linseed 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 that prevailed during kharif 1979-80 and 1987-88 season, the following observations were made and appear to be of worth consideration***
  - 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 (3/7 years). If period of drought approaches 8-10 days, 25% yield could be compensated by one life saving irrigation (5 cm depth)

State	District	Region
Uttar Pradesh	Saharanpur (Ganga – Yamuna Doab, Uttar Pradesh)	Medium runoff and High yield gap

Agro-geographic setting	Saharanpur
Climate	Hot dry/ moist sub humid (transitional)
Soils	Inceptisols – 100% Deep loamy to clayey alluvium - derived soils
Annual rainfall (mm)	1164
Potential evapotranspiration (mm)	1334
Length of growing period (LGP) / moisture availability period (days)	120 – 150

Soil and water conservation

- Compartmental bunding after seedling emergence
- Contour farming
- Graded border strips
- Sowing across the slope and ridging later
- To mitigate early season drought, one extra inter cultivation along with straw mulch @ 5 t/ha is effective.
- One protective irrigation is only solution to control late season drought effect during summer.
- Deep tillage during summer and making compartmental bunding after seedlings emergence.
- Criss-cross ploughing by country plough after each effective rainfall.
- 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 the adverse effect of late season drought.

Crop management

- **Varieties :** Hy. Ganga –5, Hy. Ganga safed-2, Jaunpuri
- **Nutrient management :** 80 kg N + 40 kg P_2O_5 + 30 kg K_2O

Farm Implements / tools

- Dryland weeder is quite effective and economic in controlling the weeds in both seasons

Alternate farming systems

- **Fodder/green biomass**: *A.indica, Leucaena, A. lebbeck, H. binata, Pongamia, C. siamea, Bauhinia*
- **Fruit:** Mango, gauva, Amla, Phalsa, Jamun, Caronda
- **Medicinal & Aromatic Plants:** *Papaver somniferum, Palma rosa, Cymbopogan flexuosus, Vetiveria zyzanoides*
- **Vegetables:** Tomato, Chillies, Brinjal, Okra, Bottle gourd, Amaranth, Cowpea.
- **Animal component:** Female Cattle, Female Buffaloes, Goat, Poultry

Contingent planning

- *Kharif*
- Under normal rainfall :
    - Pearlmillet (Proagro-9402), pigeonpea (UPAS-120), greengram (K-851), clusterbean (RGC-197)
- As the monsoon progresses
- 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) , and Taramira (TMH-1) and safflower in the order.

Prioritised cultural options for rainfed maize based production system

State	District	Prioritised Options	Avg yield (kg/ha)	Expected yield (kg/ha)
Andhra Pradesh	Nizamabad	*In situ* Soil conservation. Improved crop varieties	2702	2972 to 3107
	Adilabad	Management of surplus water and pest for rise in productivity	1540	1771 to 1848
	Medak, Warangal	Management of surplus water and pest for rise in productivity	1990	2289 to 2388
Chattisgarh	Surguja	Extension efforts for better adoption of improved varieties, better management technologies including water management for productivity improvement	1038	1246 to 1298
	Bastar, Bilaspur	Extension efforts for better adoption of improved varieties, better management technologies including water management for productivity improvement	1372	1646 to 1715
Gujarat	Kaira, P.Mahals	Extension efforts for better adoption of improved varieties, better management technologies including water management for productivity improvement	1197	1436 to 1496
Haryana	Ambala	Management of surplus water and pest for rise in productivity	1540	1771 to 1848
Jharkhand	Palamu	Extension efforts for better adoption of improved varieties, better management technologies including water management for productivity improvement	763	916 to 954
	Dumka	Extension efforts for better adoption of improved varieties, better management technologies including water management for productivity improvement	1372	1646 to 1715
Karnataka	Dharwad	*In situ* Soil conservation. Improved crop varieties	2702	2972 to 3107
	Mysore, Shimoga	*In situ* Soil conservation. Improved crop varieties	3072	3379 to 3533
Madhya Pradesh	Khargone, Shajapur	Management of surplus water and pest for rise in productivity	1540	1771 to 1848
	Betul, Dewas, Indore Jhabua, Ratlan, Shivpuri, Sidhi	Extension efforts for better adoption of improved varieties, better management technologies including water management for productivity improvement	1197	1436 to 1496

	Guna, Shahdol	Extension efforts for better adoption of improved varieties, better management technologies including water management for productivity improvement	1038	1246 to 1298
	Mandla	Extension efforts for better adoption of improved varieties, better management technologies including water management for productivity improvement	1372	1646 to 1715
Maharastra	Dhule	Better management practices including *in situ* management practices and high yield cultivars for productivity increase	875	1050 to 1094
Orissa	Ganjam, Kalahandi, Phulbani	Extension efforts for better adoption of improved varieties, better management technologies including water management for productivity improvement	1038	1246 to1298
	Koraput	Extension efforts for better adoption of improved varieties, better management technologies including water management for productivity improvement	1372	1646 to 1715
Punjab	Roopnagar	Management of surplus water and pest for rise in productivity	1540	1771 to1848
	Gurdaspur	Extension efforts for better adoption of improved varieties, better management technologies including water management for productivity improvement	1372	1646 to1715
Rajasthan	Bhilwara, Udaipur Dungarpur	Better management practices including *in situ* management practices and high yield cultivars for productivity increase	875	1050 to 1094
	Tonk	Better management practices including *in situ* management practices and high yield cultivars for productivity increase	629	755 to 786
	Banswara, Kota	Better management practices including *in situ* management practices and high yield cultivars for productivity increase	858	1030 to 1073
	Bundi, Jhalawar	Extension efforts for better adoption of improved varieties, better management technologies including water management for productivity improvement	1197	1436 to 1496
Uttar Pradesh	Unnao	Better management practices including *in situ* management practices and high yield cultivars for productivity increase	858	1030 to 1073
	Kheri, Sitapur	Extension efforts for better adoption of improved varieties, better management technologies including water management for productivity improvement	763	916 to954
	Kanpur	Management of surplus water and pest for rise in productivity	1540	1771 to1848
	Ballia, Hardoi, Jaunpur, Saharanpur	Extension efforts for better adoption of improved varieties, better management technologies including water management for productivity improvement	1197	1436 to 1496
	Badaun	Extension efforts for better adoption of improved varieties, better management technologies including water management for productivity improvement	1197	1436 to 1496

SORGHUM BASED PRODUCTION SYSTEM

Sorghum is the third important food grain crop of the country. It is the major food and fodder crop under the semi-arid agriculture currently occupying 11-12 mha area. India, tops among the nine major sorghum growing countries in the world, ranks second in grain production and seventh in productivity. The productivity of sorghum in India is five times lower than the first ranking country. Major reasons for this low yield are that nearly 60% of the crop area falls under sub-marginal agro-climatic and edaphic conditions, which are low in fertility of soil with recurring moisture stress. Sorghum is grown during rainy (*kharif*) and post rainy (*rabi*) seasons. About 55% area is under *kharif* season contributing 66% of production and 45% area under *rabi* season contributing 34% of production data. Nearly 20% of *kharif* area is used to produce dual-purpose sorghum with low emphasis on grain yield. In addition, it is believed that forage sorghum is grown in about 2.6 mha, which is not properly documented.

Kharif sorghum is grown in 13.1 mha in 346 districts out of which 7.5 mha is rainfed. About 85% of the rainfed area (5.8 m.ha) is in 71 districts.

Selection criteria	No. of Districts	Area under *kharif* sorghum ('000 ha)	Area under rainfed *kharif* sorghum ('000 ha)	Gross cropped area ('000 ha)	Yield (kg/ha)
Rainfed states (13)	346	13138	7538	167868	613
AESR 3-13	261	12303	6880	131273	714
Cumulative 85% Rainfed *kharif* sorghum area	71	8310	5829	44517	835

The trends in area, production and productivity of Sorghum in India (1980 - 2005) are shown in Fig. 5.

The trends in area and yield of sorghum in different districts

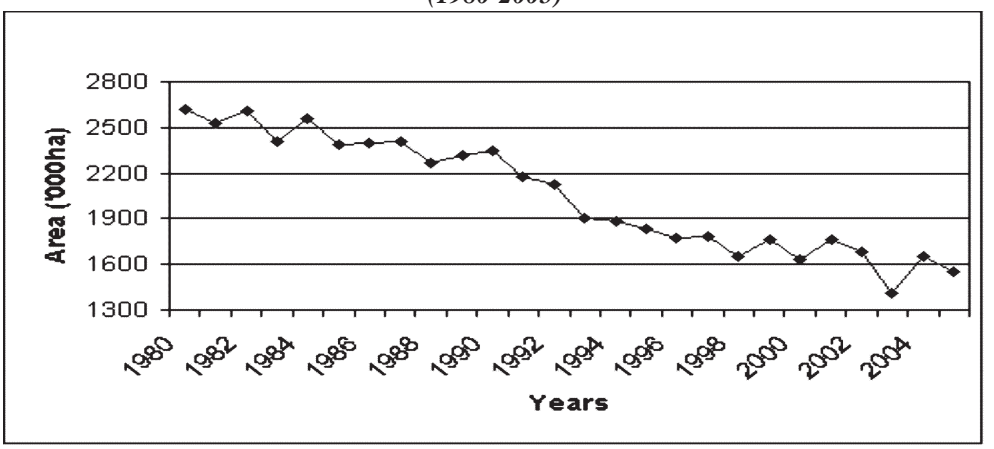
Area	Production	Productivity	State
Decreasing	Stable	Stable	Haryana
Decreasing	Increasing	Increasing	Uttar Pradesh
Decreasing	Stable	Increasing	Rajasthan
Decreasing	Decreasing	Increasing	Gujarat, Madhya Pradesh
Decreasing	Decreasing	Stable	Maharastra
Decreasing	Decreasing	Decreasing	Karnataka, Tamil Nadu

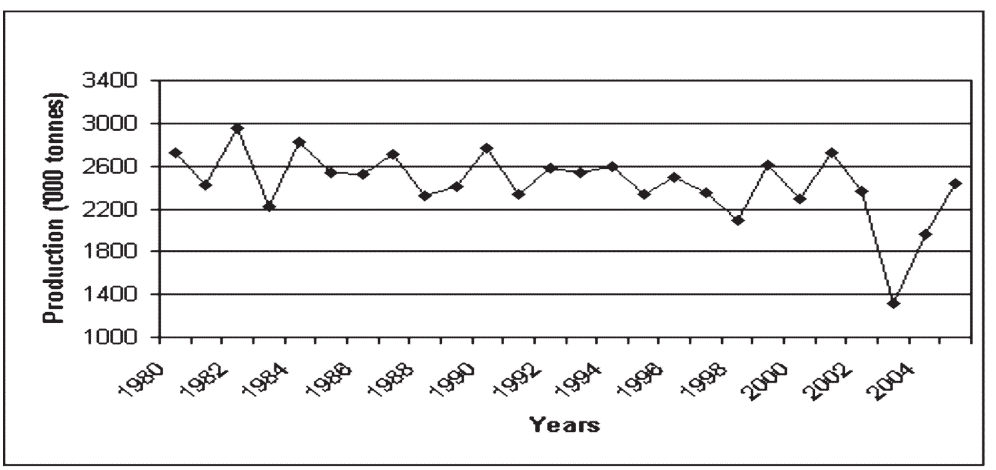
Farming systems

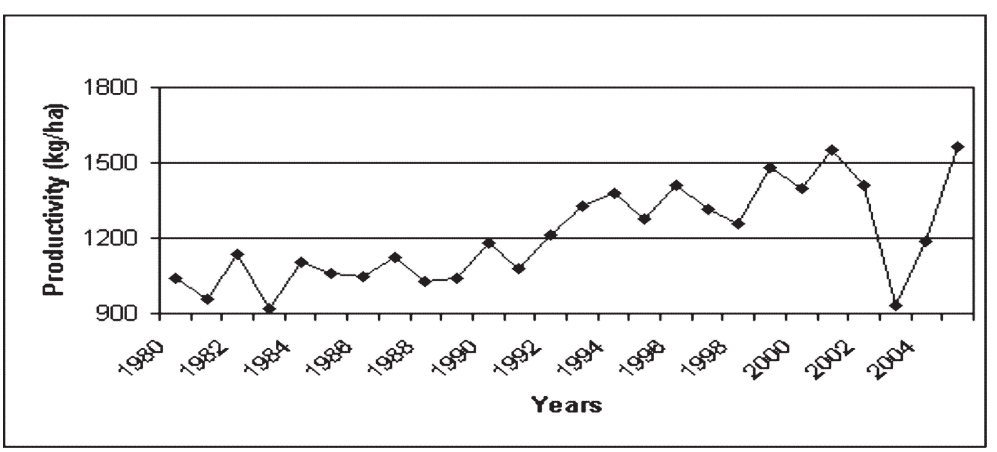
Details on associated crops and their percent area covered and spread of livestock population are presented below:

Crops	Animals	Districts
Sorghum Soybean Chickpea Maize	Goat Female Buffalo Sheep Male Buffalo	Chhindwara, Chhatarpur, Guna, Ratlam, Ujjain, Mandasur, Dewas, Dhar, Jhabua, Khargone, Khandwa, Betul, Shajapur, Mysore, Coimbatore, Nanded, Buldhana, Akola, Amaravthi, Yeotmal, Wardha, Ahmednagar, Amreli, Bhavnagar, Mehsana, Surendranagar, Jhalawar, Kota, Rohtak, Lalitpur, Hamirpur, Banda, Dharmapuri, Latur, Baran
Sorghum Chickpea Pearlmillet Maize Rapeseed Mustard	Goat Sheep Female Buffalo Male Buffalo	Shivpuri, Bhilwara, Tiruchirapalli Jaipur, Sawai Madhopur Fatehpur, Jhansi

Fig. 5. Trends in Area, Production and Productivity of Sorghum (1980-2005)







GUJARAT

In Gujarat there are five districts viz. Amreli, Bhavnagar, Mehsana, Ahamadabad and Surendranagar under low runoff and high yield gap region. The trends in area, production and productivity of sorghum in Gujarat (1980 - 2005) are shown in Fig. 6.

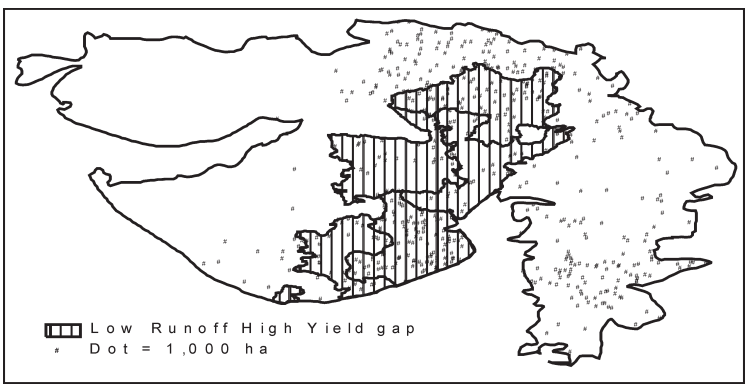
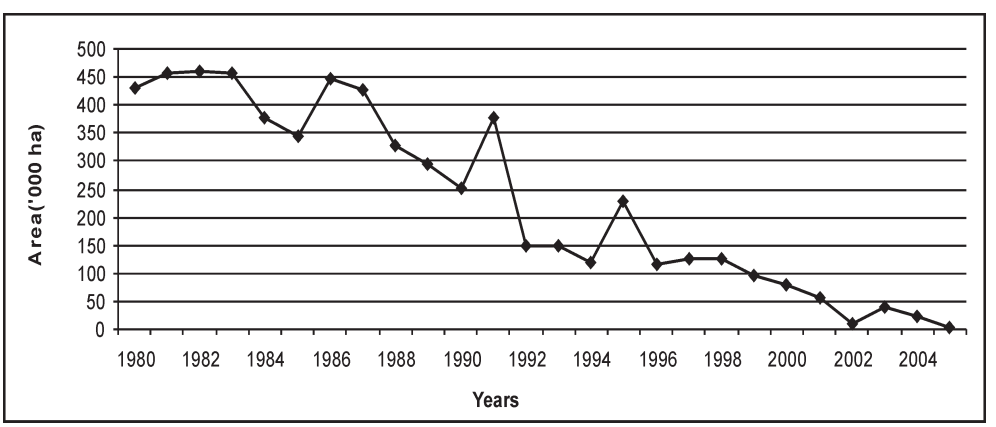
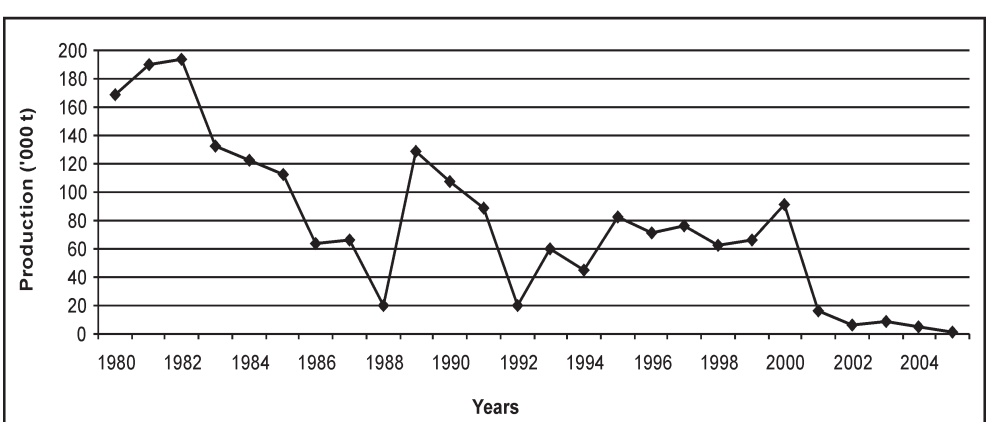
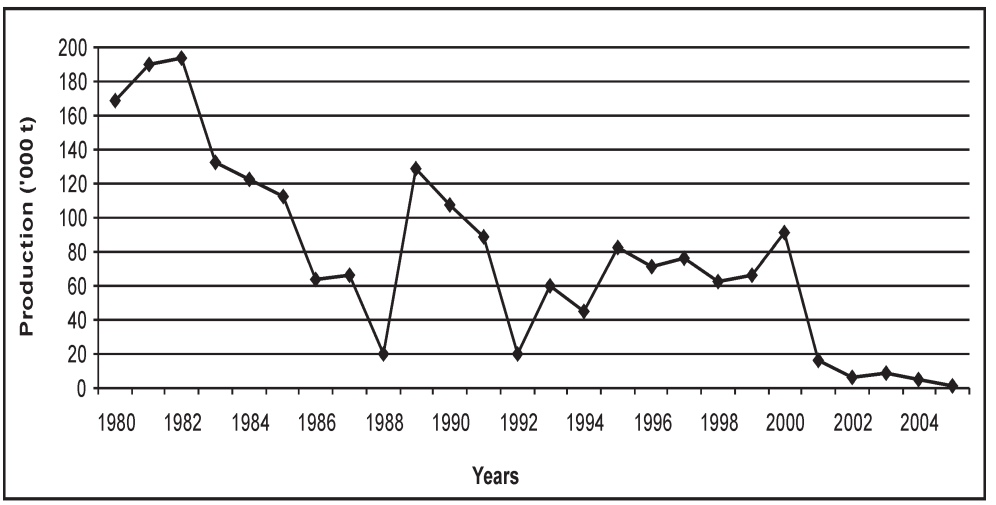


Fig. 6. Trends in Area, Production and Productivity of Sorghum in Gujarat (1980-2005)







State	District	Region
Gujarat	Amreli (Coastal Kathiawad) Bhavnagar (Central Kathiawad Peninsula) Mehsana and Ahmedabad (North Gujarat Plains) Surendranagar (North Kathiawad Peninsula)	Low runoff and High yield gap

Agro-geographic setting	Amreli	Bhavnagar	Mehsana	Ahmedabad	Surendranagar
Climate	Hot dry semi arid, Hot moist semi arid	Hot dry semi arid, Hot moist semi arid	Hot arid, Hot dry semi arid	Hot dry semi arid	Hot arid, Hot dry semi arid
Soils	Orthids – 100%, Shallow and medium loamy to clayey black soils, deep black soils Deep loamy coastal alluvium -derived soils	Orthids – 75%; Vertic soils–25% Deep loamy gray brown and alluvium - derived soils, Shallow and medium loamy to clayey black soils, deep black soils,	Ustalf/ Ustolls – 100% Deep loamy coastal alluvium - derived soils Deep loamy desert soils Deep loamy grey brown and alluvium - derived soils	Ustalf/ Ustolls – 100% Deep loamy grey brown and alluvium - derived soils Shallow and medium loamy to clayey black soils, deep black soils	Ustalf/ Ustolls – 60%; Vertic soils – 40% Deep loamy desert soils Deep loamy saline and alkaline soils Deep loamy grey brown and alluvium - derived soils
Annual rainfall (mm)	607	602	507	823	601
Potential evapotranspiration(mm)	1877	1814	1988	1678	1970
Length of growing period (LGP)/moisture availability period (days)	90-150	90-150	90-150	90-120	60-120

Soil and water conservation

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

Crop management

- **Varieties :** GJ-39, GJ-40, GJ-41, GJ-42 - Suitable for mono and inter-cropping systems GFS- 4 – For fodder
- **Seed rate:** 8 kg/ha for grain sorghum and 20 kg/ha for fodder sorghum
- **Planting Pattern:** 45 x 15 cm
- **Nutrient management**
  - 90 kg N + 30 kg P_2O_5 **:** N in 3 splits 25% as basal + 50% at tillering + 25% at flag leaf stage or 2 splits 50% as basal and 50% at tillering
  - For dual purpose sorghum, CSV-15, SPV-1616, apply 60 kg N and 30 kg P_2O_5 / ha
  - Apply Nitrogen in three splits viz., 25% as basal, + 50% at tillering and 25% at flag leaf stye
  - For fodder sorghum – apply 50 kg N/hain tow splits (25 kg at basal + 25 kg at top dressing at 45 days after)

Suitable cropping systems

- Sorghum + pigeonpea (1:1)
- In shallow and medium fertile soils, 16 rows of sorghum (CSH-5) in alley of perennial pigeonpea (ICPL-185)

Farm implements / tools

- Two bowl seed cum fertilizer drill

Alternate Farming Systems

- **Fodder/ green biomass***: Dichrostachys cineraria, A. lebbeck, Leucaena leucocephala, Pongamia pinnata*
- On slopy fallow lands with shallow soils – *Dicanthium annulatum*; 16 rows of groundnut (GG-2) in alleys of perennial pigeonpea (ICPL-185); 16 rows of groundnut (GG-2) in alleys of subabul (Hawai gaint)
- **Fruit:** Custard apple, Mango, Pomegranate Phalsa, Fig, Jamun, Tamarind
- **Medicinal/ Aromatic Plants:** *Plantago ovata, Cassia angustifolia, Liquorice.*
- **Vegetables:** Cowpea, Cluster bean, Brinjal, Okra, Long melon, Drum stick.
- **Animal Component:** Female / male cattle; she buffaloes, sheep, goat

Contingent planning

- **Delay in monsoon by**

  15th July to 31st July : Grow erect groundnut (GG-2, GG-5, GG-7), Sesame (G-Til-1, G.Til-2), Castor (GAUCH-1), Hybrid Bajra (GHB-235, GHB-316, GHB-558), Greengram (K-851, GM-4), Blackgram (T-9, TPU-4), Pigeonpea (ICPL-87, GT-100)

1st August to 14th August : Grow pulses blackgram (T-9, TPU-4), forage maize / sorghum (Gundri, GFS-5), castor (GAUCH-1, GC-2) and sesamum (Purva-1)

15th August to 31st August: Grow forage maize / sorghum (Gundri, GFS-5), sesamum (Purva-1)

- **Drought spell after normal sowing**

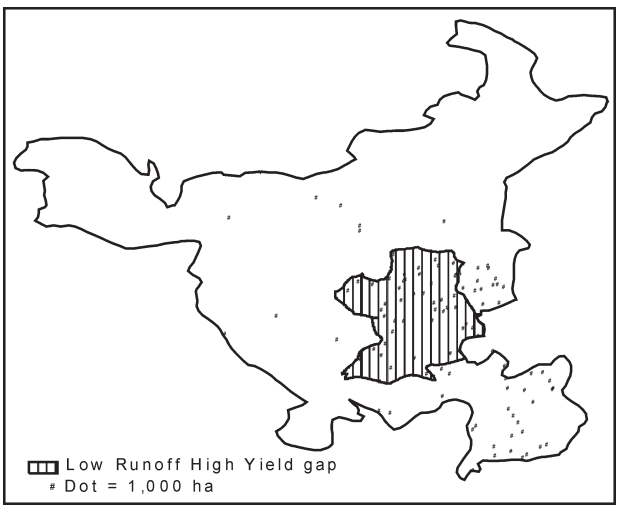
  1-2 weeks after sowing : Resowing of early duration varieties or alternate crops should be recommended as under, if sufficient rainfall is received. Hybrid bajra (GHB-235, GHB-316, GHB-558), sorghum (GJ-39, J-41), sesamum (G.Til-1, G-Til-2) and castor (GAUCH-1, GC-2), blackgram (T-9, TPU-4)

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

- **Early withdrawal of monsoon**
  - Give life saving irrigation
  - Minimize moisture losses through complete removal of weeds
  - Perform interculturing to conserve soil moisture
  - Harvest the crop according to maturity of crop duration
  - Thin the plant population
- **Satisfactory late rains during September - October**
  - Relay cropping of castor, sunflower, sesame (Purva-1) and fodder sorghum
  - Second crops like mustard and chickpea could be taken
  - Ratooning of sorghum

HARYANA

In Haryana there is one district viz. Rohtak under low runoff and high yield gap region. The trends in area, production and productivity of sorghum in Haryana (1980 - 2005) are shown in Fig. 7.



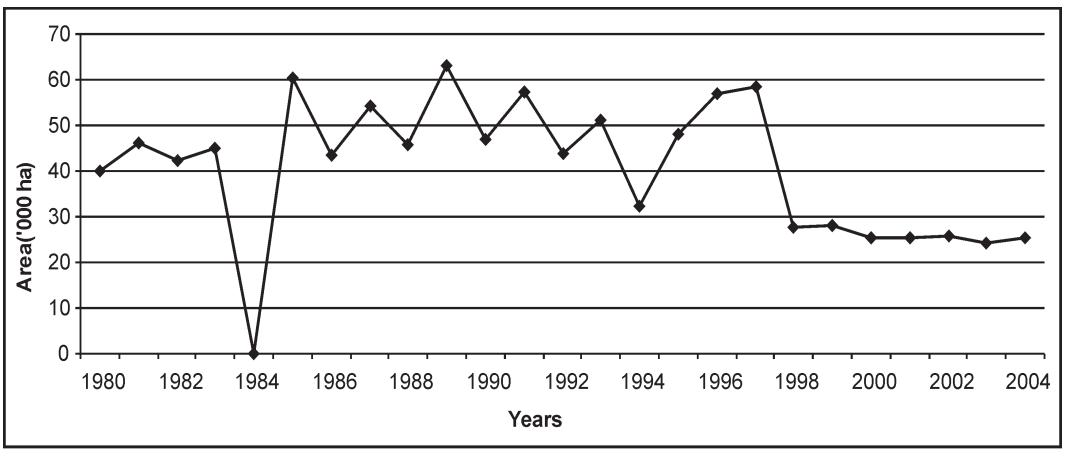
State	District	Region
Haryana	Rohtak (South East Haryana)	Low runoff and High yield gap

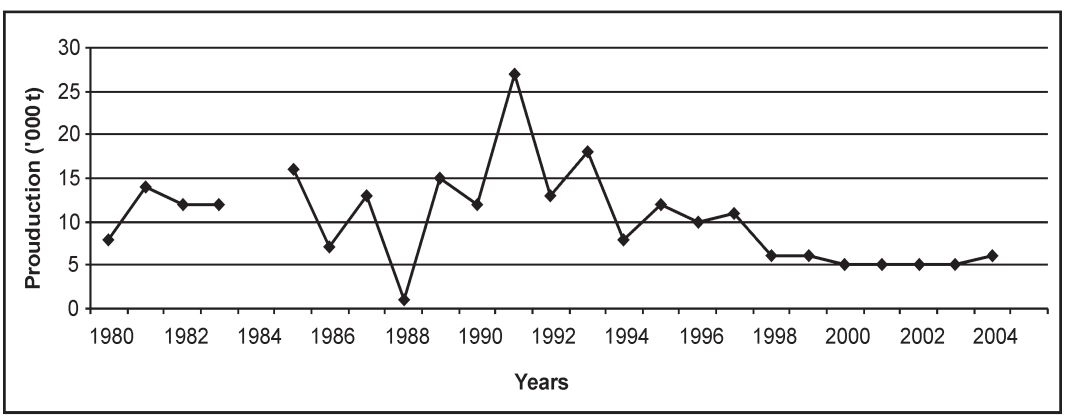
Agro-geographic setting	Rohtak
Climate	Hot semi arid
Soils	Inceptisols – 100%, Deep loamy alluvium - derived soils
Annual rainfall (mm)	511
Potential evapotranspiration (mm)	1636
Length of growing period (LGP) / moisture availability period (days)	90-120

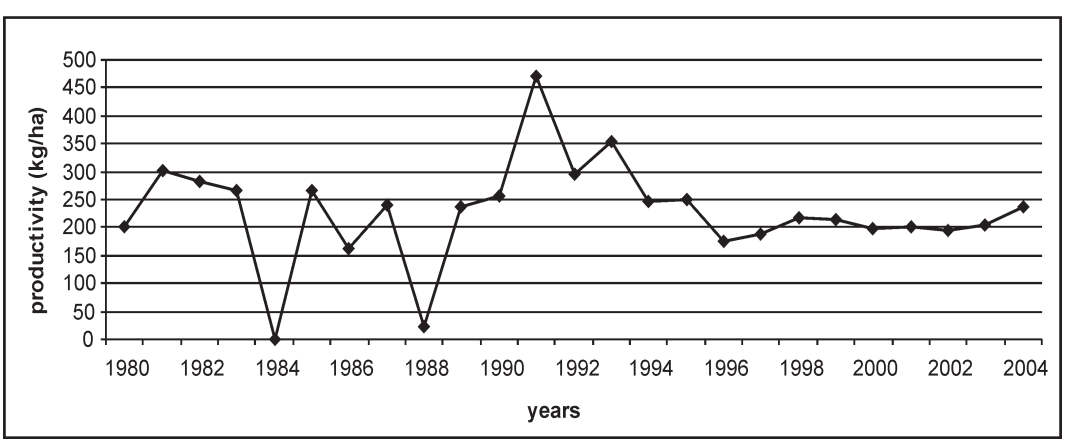
Soil and water conservation

- Increasing soil infiltration capacity and reducing soil crusting problem
- Inter-plot water harvesting of 1:1 cropped to uncropped land
- Dead furrows at 3.6 m intervals
- Land shaping
- Pre monsoon/ summer tillage and ridge furrow configurations across the land slope to improve moisture storage.
- Indigenous water harvesting structures

Fig. 7. Trends in Area, Production and Productivity of Sorghum in Haryana (1980-2005)







Crop management

- **Varieties :** HC 308, HC136, SSG 59-3
- **Seed rate :** 5-6 kg/ha
- **Planting pattern :** 25 cm row to row
- **Nutrient management :** 80 kg N + 40 kg P_2O_5

In the absence of information about sorghum crop, the above relevant crop management practices are taken from Jhansi district. However, locally available information about sorghum from the nearest research center may be used.

Farm implements / tools

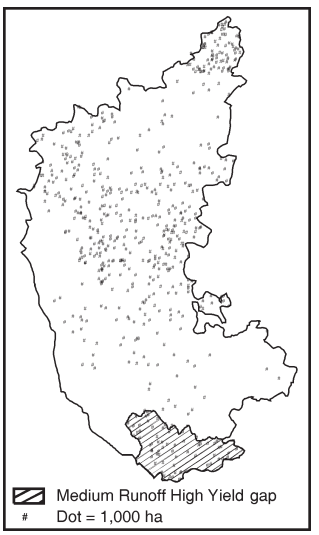
- Use of blade type wheel hand hoe to save time and energy for interculture operations
- Tactor – drawn ridger –seeder (3 Point hich tools)
- Bullock-drawn Ridger seed drill
- Bulloc-drawn interculture blade harrow
- Hand wheel Hoe

Alternate Farming Systems

- **Fodder/ green biomass:** Agri-Horti system of ber intercropped with cowpea, greengarm, clusterbean, berseem, lucerne and anjan grass.
- *A.lebbeck, P.cineraria, Melia azadirachta [for saline soils], D.sissoo, A.indica.*
- **Fruit :** Guava, Amla, Karonda, Phalsa, Bael, Jamun
- **Medicinal & Aromatic Plants :** *Plantago ovata, Palma rosa, Vetiveria zyzanoides, Ocimum viride, Liquorice.*
- **Vegetables :** Tomato, Chillies Okra, Cow pea, Palak, Bottle gourd
- **Animal Component:** Female Buffaloes, Sheep

KARNATAKA

In Karnataka there is one district viz. Mysore under medium runoff and high yield gap region. The trends in area, production and productivity of sorghum in Karnataka (1980 - 2005) are shown in Fig. 8.



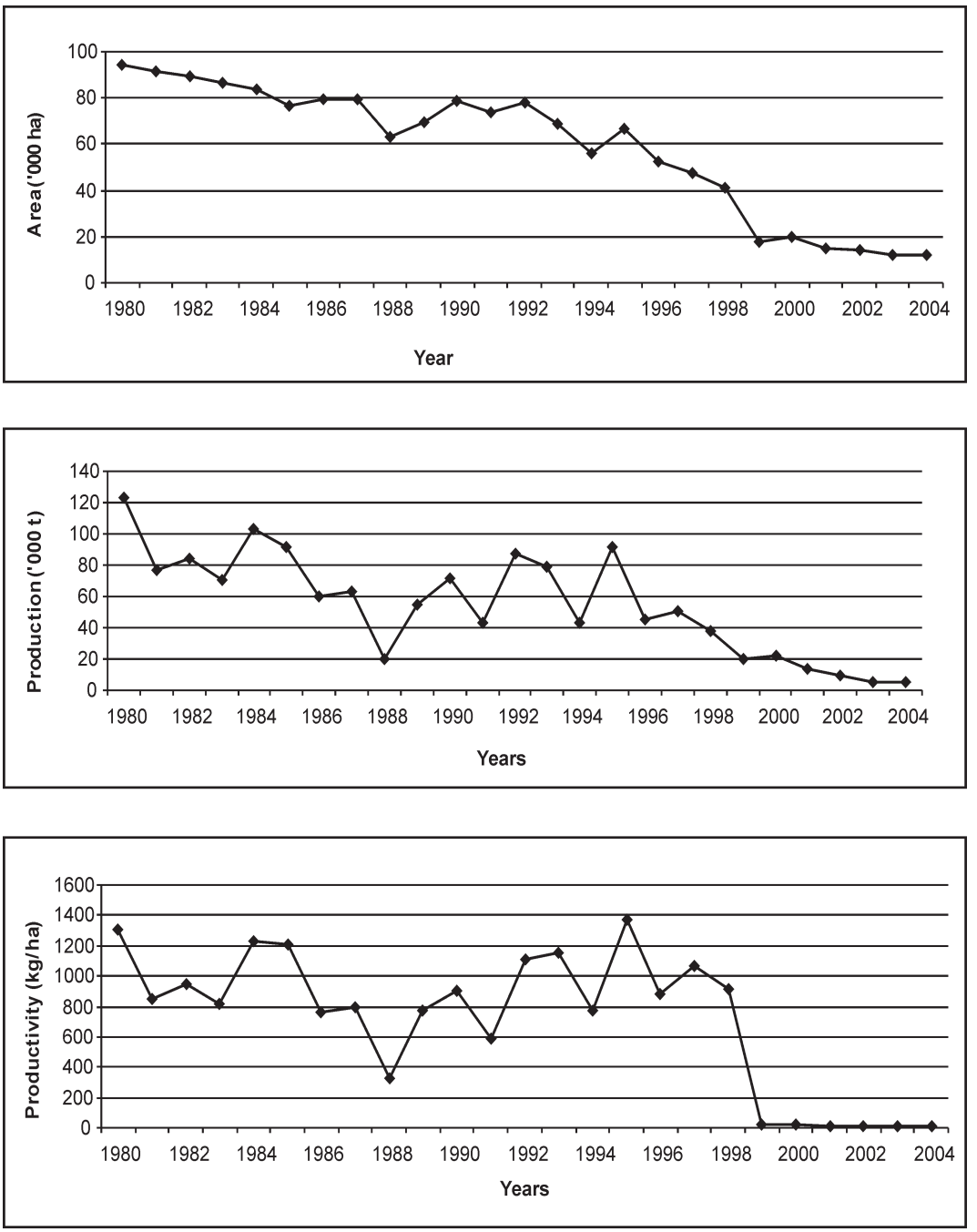
State	District	Region
Karnataka	Mysore (Central Karnataka)	Medium runoff and High yield gap

Agro-geographic setting	Mysore
Climate	Hot moist semi arid
Soils	Sandy Alfisols – 100%, Medium to deep red loamy soils
Annual rainfall (mm)	920
Potential evapotranspiration (mm)	1535
Length of growing period (LGP) / moisture availability period (days)	120-150

Soil and water conservation

- **Long term Conservation practices:**
  - Construction of contour bunds with a cross section of 0.54 Sq. m to control and conserve runoff.
  - Construction of graded bunds by providing 0.2 to 0.4 per cent grade with a cross section of 0.36 Sq. m for safe disposal of excess runoff.
  - Graded broader strips with a gradient of 0.1 to 0.5 per cent to fit into the local topography and hydrographic features.
  - Broad based bunds of 1.5 Sq.m. cross sections on contour with 1 m vertical interval for better rainwater conservation.
  - Reduced contour bunds (0.36 Sq. m) in combination with vegetative live barriers for effective conservation of rainwater in low rainfall areas (< 600 mm)

Fig. 8. Trends in Area, Production and Productivity of Sorghum in Karnataka (1980-2005)



- ***In-situ* Conservation practices:**
  - Opening a dead furrow in between the paired rows in pigeonpea and maize for better moisture conservation.
  - Graded ridge and furrows are made on 0.2 to 0.4 per cent grade for better conservation of moisture as well as safe disposal for cultivation of maize.
  - Fall ploughing to a depth of 15-30 cm. for better infiltration of rainwater during onset of rains.
  - Deep tillage to a depth of 25-30-cm. using mould board plough to reduce the weed incidence and increase soil moisture storage for sunflower and maize crops.
  - Crop cultivation across the slope with Vetiver/ pennisetum grass as live barrier at 0.5 m vertical interval to check the velocity of runoff and better moisture conservation and availability for a longer period for Finger millet/groundnut/maize/sunflower crops.

Crop management

- **Varieties :** For Fodder Sorghum : J – Set –3, MP- Chari, GS-20, Pusa Chari, S- 1049, Salabani, Pioneer x 988, SSG – 59 – 3, HC 308, HC 136
- **Seed rate:** 7.5 kg/ha for grain sorghum, 20-25 kg/ha for forage sorghum
- **Planting Pattern :** 25 row to row spacing
- **Nutrient management :** 10 t FYM /ha + 65 kg N + 40 kg P_2O_5 + 40 kg K_2O. N in two splits i.e., ½ at sowing and ½ at 30 days after sowing **.**

Suitable cropping systems

- Sorghum – pigeonpea

Farm implements / tools

Tools/Implements	Cost/Unit(Rs.)	Operation
Bullock drawn seed-cum-fertilizer drill (Finger millet)	1500/-	Bullock drawn manual operation for finger millet seeding and fertilizer application(Hand metered)
Bullock drawn seed-cum-fertilizer drill (Groundnut)	1500/-	Groundnut seeding with fertilizer application
Multifurrow opener	1300/-	Opening furrows for hand seeding of different crops
Bent tyne hoe	350/-	Intercultural operation for finger millet
Duck foot hoe	350/-	Intercultural operation for finger millet and groundnut for moisture conservation (Hand metered)
Crust brakes	500/-	For breaking the crust to facilitate smooth emergence of the seedling in finger millet and groundnut.

Alternate Farming Systems

- **Fodder/ green biomass:** *Casuarina, silveroak, Glyricidia, Caliandra, Faidherbia albida* on bunds Gravelly shallow soils – *Stylosanthes cabra*
- High gradient non-arable lands with shallow soils – Amla In catche pits with deep soils – *Azadhiracta indica, pongamia, Albizzia lebbek*

- **Forage crops** – *Pennisetum, pedicallatum / cenchrus ciliaris, microtaliem axillaries, maize – African tall, sorghum for fodder*
- **Fruit:** Mango, Pomegranate, Sapota, Guava, Custard apple, Jamun
- Wastelands – JackFruit, custard apple, tamarind
- **Medicinal/ Aromatic Plants:** *Catharanthus roseus, Cassia angustifolia, Salanum viarum, Dioscrorea, Geranium, Pogostemon patchouli, Jasmine*
- **Vegetables:** Tomato, Chillies, Okra Water melon, Bitter gourd, Drum stick, Brinjal, Bitter gourd.
- **Animal Component:** Male / female cattle, female buffaloes, poultry, sheep, goat,
- **Other enterprises;** Mushroom cultivation, sericulture, piggery, apiary, rabbit rearing

Contingent Planning

Month and Fortnigh (FN) in which normal rains occur	Crops that could be sown	
	Monocropping	Double cropping
April-II FN		Sesamum or greengram
May I FN	Pigeonpea	Sesamum, cowpea, Greengram, Urd bean, Fodder maize, Fodder Bajra, Fodder Jowar
May-II FN	Pigeonpea	Sesamum, cowpea, Greengram, Urd bean, Fodder maize, Fodder Bajra, Fodder Jowar
June-I FN	Long duration Finger millet, Pigeonpea, Maize, Groundnut	F.maize, F.Jowar, F.Bajra, Cowpea
June-II FN	Long duration Finger millet, Pigeonpea, Maize and Groundnut	Sowing of chilli nursery
July-I FN	Groundnut , long duration finger millet	Sowing of Chilli nursery
July-II FN	Groundnut, long/medium duration fingermillet	Sowing of Chilli nursery
August-I FN	Cowpea, Horsegram, short duration fingermillet, transplanting chilli	Cowpea, Horsegram, short duration finger millet, transplanting chilli. Sowing of chilli nursery and short duration finger millet.
August II FN	Short duration finger millet, transplanting of medium and long duration finger millet. Transplanting chilli. Cowpea, Horsegram	Short duration fingermillet, transplanting of medium and long duration finger millet, transplanting chilli. Cowpea.Horsegram. Also, Fodder crops (Maize-Bajra, Jowar)
September I FN	Horsegram, Transplanting of short duration finger millet and chilli (with protective irrigation)	Horsegram, Transplanting of short duration finger millet and chilli(with protective irrigation)

MADHYA PRADESH

In Uttar Pradesh there are ten districts viz. Dewas, Chhindwara, Khargone, Mandsaur, Dhar, Ujjain, Ratlam, Betul , Shahjapur and Chattarpur under medium runoff and high yield gap region. The trends in area, production and productivity of sorghum in Madhya Pradesh (1980 - 2005) are shown in Fig. 9.

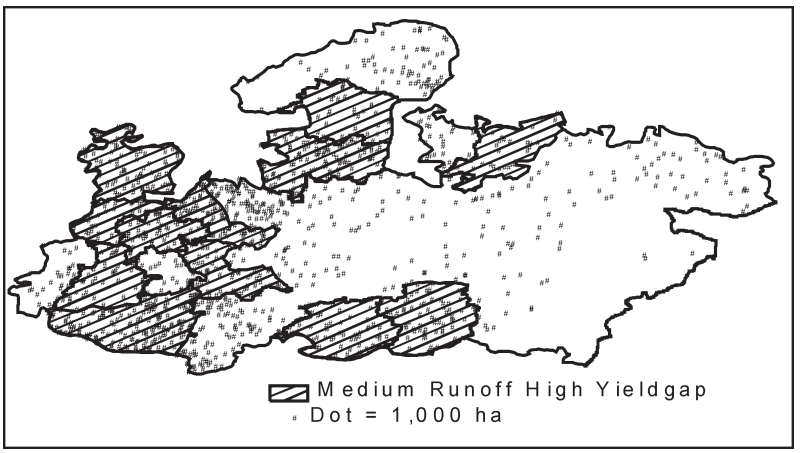
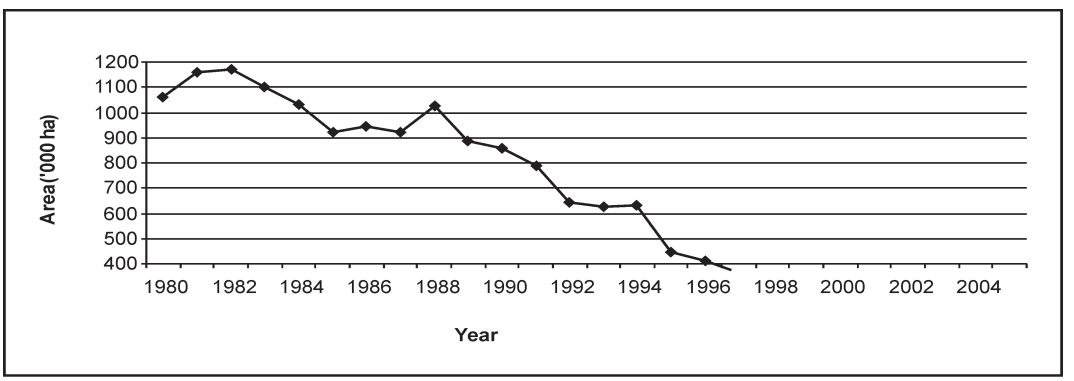
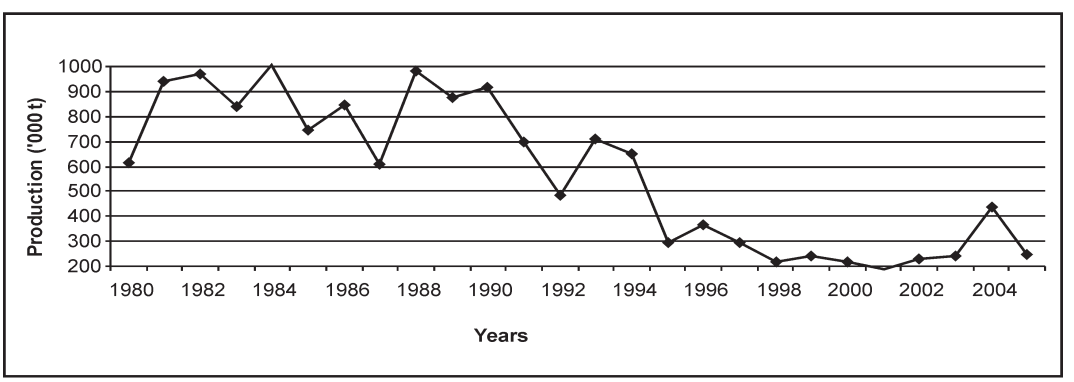
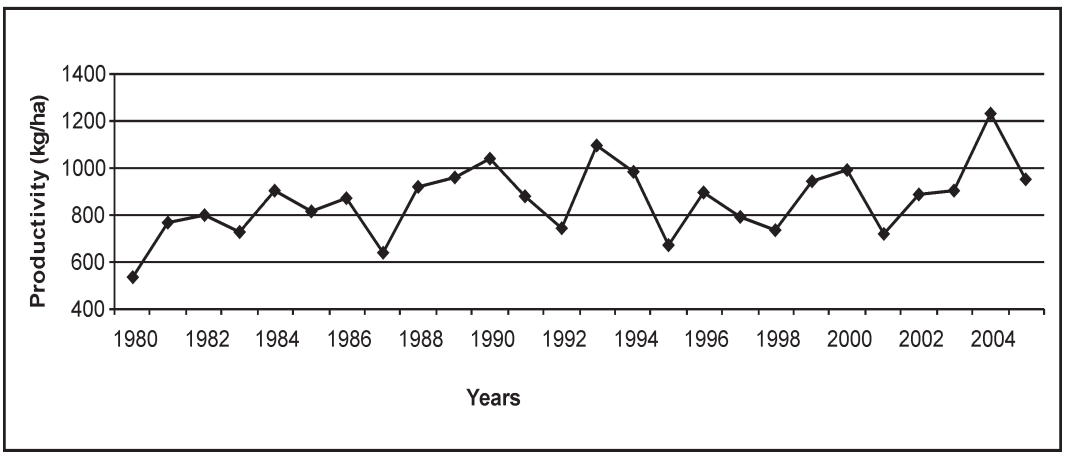


Fig. 9. Trends in Area, Production and Productivity of Sorghum in Madhya Pradesh (1980-2005)







State	District	Region
Madhya Pradesh	Dewas (Central West Madhya Bharat Plateau) Chhindwara (Central South Madhya Pradesh Satapura ranges) Khargone, Mandsaur, Dhar, Ujjain and Ratlam (Western Malwa Plateau) Betul (Southern Madhya Pradesh) Shahjapur (Malwa Plateau) Chattarpur (Vindhyas scrapland)	Medium runoff and High yield gap

Agro-geographic setting	Dewas	Chhindwara	Khargone	Mandsaur	Dhar
Climate	Hot moist semi arid Hot dry sub humid	Hot moist sub humid		Hot moist semi arid	Hot moist semi arid
Soils	Vertic soils – 100% Deep clayey black soils, shallow black soils, Medium and deep clayey black soils, shallow loamy black soils	Vertic soils-85% Vertisols – 15% Shallow to deep loamy to clayey mixed red and black soils	Vertic soils–100% Deep black soils, shallow black soils, Medium and deep clayey black soils, shallow loamy black soils	Vertic soils–100% Deep clayey black soils, shallow black soils	Vertic soils–100% Deep clayey black soils, shallow black soils
Annual rainfall (mm)	1079	1094	888	962	915
Potential evapotranspiration(mm)	1707	1427	1792	1601	1692
Length of growing period (LGP) / moisture availability period (days)	120-180	180-210	120-180	120-150	120-150

Agro-geographic setting	Ujjain	Ratlam	Betul	Shahjapur
Climate	Hot moist semi arid	Hot moist semi arid	Hot dry sub humid	Hot moist semi arid Hot dry sub humid
Soils	Vertic soils – 100%, Deep clayey black soils, shallow black soils	Vertic soils – 100%, Deep clayey black soils, shallow black soils	Vertic soils – 85%; Vertisols – 15% Shallow and medium loamy to clayey black soils, deep clayey black soils	Vertic soils– 90%; Vertisols–10% Deep clayey black soils, shallow black soils Medium and deep clayey black soils, shallow loamy black soils
Annual rainfall (mm)	1088	1078	1129	1117
Potential evapotranspiration (mm)	1656	1521	1370	1643
Length of growing period (LGP) / moisture availability period (days)	120-150	120-150	150-180	120-180

Soil and water conservation

- Raised and sunken beds (8:4 m wide with elevation difference of 0.15 to 0.20 m) prove most effective in *in-situ* rain water conservation and controlling nutrient and soil losses.
- Construction of percolation tank or any suitable water storage structures at suitable site for increasing ground water recharge and enhancing ground water storage to provide extra irrigation to the crop.
- 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 retrain the excess run off from the water shed area to use stored water for irrigation purpose.
- Silpaulin (a plastic material) of 90 – 120 gsm has been found effective lining material for farm ponds used for water harvesting purposes.
- Use vegetative barriers to strengthen the mechanical bunds at suitable vertical intervals in order to reduce run off in associated soil losses from the cultivated fields.
- Develop a sort of terracing break the continuity of undulating slope to reduce the chances of degrading cultivated cultivated fields in to gullied one.
- Use mould board plough for deep tillage to increases the productivity of *kharif* crops and ensure sowing of *rabi* crop through better moisture conservation and eradication of infested weeds.
- 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 kahrif crops and enhance sowing of *rabi* crops through better moisture conservation and eradication of infested weeds.
- Graded bunds alone and / or along with vegetative barriers at vertical intervals of 50 cm proves most effective in controlling soil erosion and nutrient losses on soils having slope up to 2 per cent.

- Off-season shallow tillage is important not only in controlling the weeds but also in helping entry of rain water.
- 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.

Crop management

- **Hybrids:** CSH-14 and CSH-18, SPV-1616

  V**arieties :** JJ-741, JJ-938, JJ-1041
- **Seed rate:** Varieties : 8 – 10 kg/ha kg/ha

  Hybrids: 5 –6 kg/ha
- **Planting Pattern:** Varieties : 45 x 12- 15 cm

  Hybrids: 45 x 15 –20 cm
- **Nutrient management :** 80 kg N + 40 kg P_2O_5/ha + 6 t/ha FYM + Azospirillum
- **Some other important practices**
  - Sowing : 2nd to 3rd week of June after the receipt of rains

Suitable cropping systems

- Intercropping : Sorghum + pigeonpea (2:2) for medium black soils
- Crop rotation : Sorghum - chickpea/safflower for deep black soils

Farm implements / tools

- **Suitable Implements For Seedbed Preparations:**
  - Meston Plough
  - Iron Bakhar
- **Suitable Implements For Sowing Operations:**
  - Mahakal Dufan
  - Mahakal Tifan and
  - Sarta attachment for intercropping
- **Suitable Implements / Tools For Interculture Ooperations:**
  - Hand dora (small blade harrow)
  - Bullock drawn dora (small blade harrow with wooden beam)
  - Indore ridger
  - Mechanically metered CIAE seed cum ferti. drill has been found most suitable for planting of soybean, sorghum and safflower followed by Malwa seed -cum -ferti drill.
- **Alternate Farming Systems**
  - **Fodder/green biomass :** *Dichrostachys cinereria, Albizia amara, Faidherbia albida, Hardwickia binata, Cassia, Leucaena leucocephala, Albizia lebbeck*

- **Fruit:** Ber, Pomegranate, Mango, Fig, Tamarind
- **Medicinal & Aromatic Plants:** *Withamnia somnifera, Rauvolfia serpentina, Vetiver zyzanoides, Palma rosa, Liquorice.*
- **Vegetables:** Chillies, Okra, Watermelon, Cowpea, Cluster bean, Amaranthus, Round melon.
- **Animal Component:** Female Cattle, Male Cattle, Female Buffaloes, Goat, Poultry

Contingent Plannning

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:

Period	Crops and their varieties recommended for planting
(A) 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
	Til – Bhadeli, TKG 22, TKG 37 etc.
	Cowpea – Pusa Komal and Pusa Baisakhi
	Castor – Gauch and Varuna.
	Fodder crops – Sorghum sudanensis, Maize- African tall, Dinanath grass and Pearlmillet etc.
(B) 1st to 15th August -	**Sunflower** – Morden, Surya, Manjira and any of the hybrids.
	Til – Bhadeli, TKG 22, TKG 37 etc.
	Cowpea – Pusa Komal and Pusa Baisakhi.
	Rajgira (Amaranthus)- Co-1 and Co-2.
	Castor- Gauch, Varuna.
	Fodder crops – Sorghum Sudanensis, Maize- African tall, Dinanath grass and Pearlmillet etc.
(C) 15th to 31st August -	**Safflower** – JSF-1, JSF- 7 (spineless), JSF-73, Sharda
	Sunflower – Morden, Surya and Manjira
	Til – Bhadeli, TKG-22, and RT-46
	Rajgira –Co-1 and Co-2.
	Castor- Gauch, Varuna.
	Fodder crops – Barley, oats, Maize- African tall, safflower and sunflower.

Agro-geographic setting	Chattarpur
Climate	Hot dry sub humid
Soils	Vertic soils 80%; Inceptisols – 20%, Deep loamy to clayey mixed red and black soils
Annual rainfall (mm)	1044
Potential evapotranspiration (mm)	1429
Length of growing period (LGP) / moisture availability period (days)	150-180

Soil and water conservation

- Broadbed furrow
- Contour farming
- Inter-plot water harvesting
- Raised bed and sunken system
- Awarshan ki sthiti mayn kisano ke likya sughhava
- Jalgrahan chhetra ke samasyayen avam prabandh

Crop management

- **Varieties :** Hybrids: CSV-15, CSH-16, CSH-18

  Varieties : JJ-741, JJ-938, JJ-1041
- **Seed rate:** Varieties : 8 – 10 kg/ha kg/ha

  Hybrids: 5 –6 kg/ha
- **Planting Pattern:** Varieties : 45 x 12- 15 cm

  Hybrids: 45 x 15 –20 cm
- **Nutrient management :** 80 kg N + 40 kg P_2O_5/ha + 6 t/ha FYM + Azospirillum
- **Some other important practices :**
  - Sowing : 2nd to 3rd week of June after the receipt of rains

Suitable cropping systems

- Sorghum + pigeonpea (2:2) for medium black soils
- Sorghum - chickpea/safflower for deep black soils

Alternate Farming Systems

- **Fodder/green biomass :** *Leucaena leucocephala, Albizzia amara, Dichrostachys cineraria, Melia azadirachta, Hardwickea binata, A.lebbeck*
- **Fruit:** Mango, Ber, Guava, Tamarind, Karonda
- **Medicinal & Aromatic Plants:** *Safed musli, Palma rosa, Withania somnifera, Papaver somniferum, Vetiveria zyzanoides*
- **Vegetables:** Brinjal, Chilli, Cowpea, Okra, Bottle gourd, Round melon.
- **Animal Component:** Female Cattle, Male Cattle, Female Buffaloes, Goats

Contingent planning

June 1) Sole crop
- a) Sorghum (CSH-16, CSH-18, JS-1041)
- b) Green gram (K-850)
- c) Blackgram (JU-2, PDU-4)
- d) Groundnut (Jawahar Jyoti, M-13)

	2) Inter crop	a) Sorghum + redgram (2 :1)
		b) Soybean + redgram (2 :1)
July	1) Sole crop	a) Rice (IR-50, JR-345)
		b) Kodo (JK-155, JK-76, JK-136)
		c) Sorghum (CSH-16, CSH-18)
		d) Pigeonpea (NPWR –15, JA-4, Asha)
		e) Groundnut (Jyoti, M 12, Exotic 1-1)
	2) Inter crop	a) Sorghum + redgram (2 :1)
		b) Soybean + redgram (2 :1)
August		a) Castor (Aruna)
		b) Pigeonpea (No.148)
October		a) Wheat (JW-17, C-306)
		b) Chickpea (JG-321, JG-315)
		c) Linseed (JL-23, R-552)
		d) Barley (Karan-4, Jyoti)
		e) Lentil (JL-1, Malika)

State	District	Region
Madhya Pradesh	Guna (North West Madhya Pradesh)	Medium runoff and High yield gap

Agro-geographic setting	Guna
Climate	Hot moist semi arid, Hot dry sub humid
Soils	Vertic soils – 100% Deep loamy and clayey mixed red and black soils, Medium and deep clayey black soils, shallow loamy black soils
Annual rainfall (mm)	1222
Potential evapotranspiration (mm)	1511
Length of growing period (LGP) / moisture availability period (days)	120-180

Soil and water conservation

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

Crop management

- **Varieties** : JJ-741, JJ-938, JJ-1041

  Hybrids : CSH-15, CSH-16, CSH-18, SPV-1616
- **Seed rate:** Varieties : 8 – 10 kg/ha kg/ha

  Hybrids : 5 –6 kg/ha

- **Planting Pattern:** Varieties : 45 x 12- 15 cm

  Hybrids: 45 x 15 –20 cm

- **Nutrient management :** 80 kg N + 40 kg P_2O_5/ha + 6t kg/ha FYM + Azospirillum

Suitable cropping systems

- Sorghum + pigeonpea
- Sorghum - chickpea

Farm implements / tools

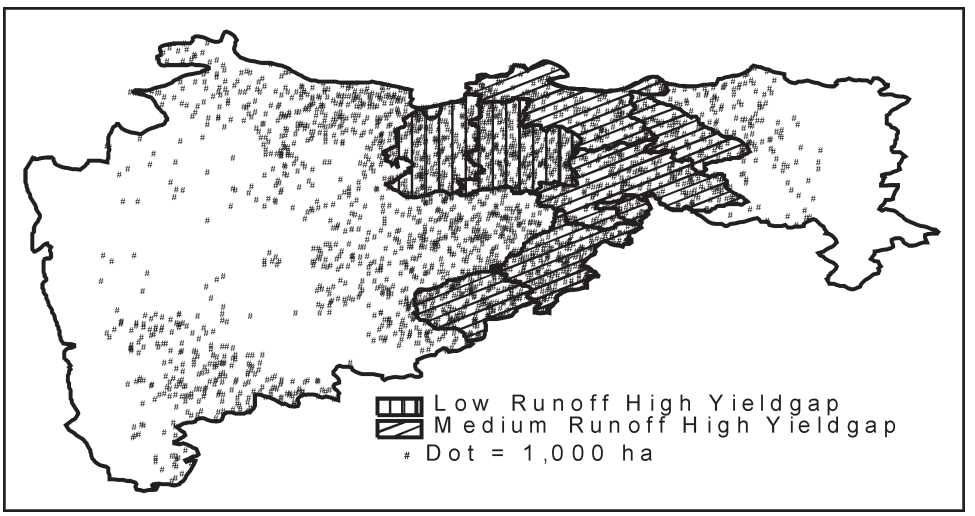
- Dryland weeder
- Seed cum ferti drill

Alternate Farming Systems

- **Fodder/ green biomass:** *Leucaena, Melia azadhirachta, Dichrostachys cineraria, Albizzia amara, A.lebbeck, Hardwickia binata, A.nilotica*
- **Fruit:** *Emblica officinalis* (amla), Guava, Ber, Mango
- **Medicinal/ Aromatic Plants:** *Rauvolfia serpentina, Vetiver zyzanoides, Palma rosa, Safed musli, Asgand.*
- **Vegetables:** Bottle gourd, Brinjal, Tomato, Chillies, Cowpea, Okra
- **Animal Component:** Female Cattle, Male Cattle, Female Buffaloes, Goat, Poultry

MAHARASHTRA

In Maharashtra there are two districts viz. Buldana and Akola under low runoff and medium yield gap region and five districts viz. Nanded, Latur, Amaravati, Yavatmol and Wardha under medium runoff and high yield gap region. The trends in area, production and productivity of sorghum in Madhya Pradesh (1980 - 2005) are shown in Fig. 10.



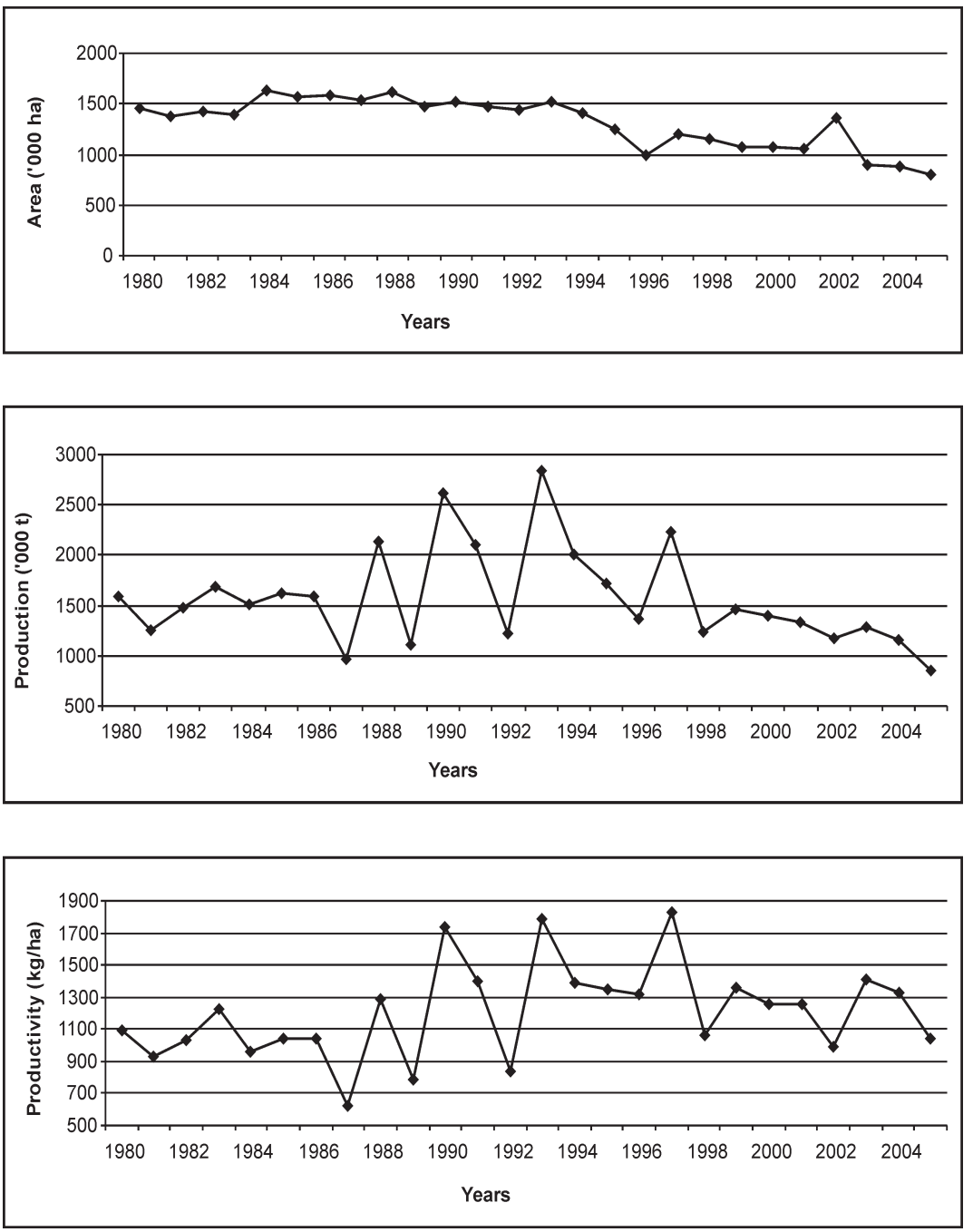
State	District	Region
Maharashtra	Buldana and Akola (Eastern Maharashtra Plateau)	Low runoff and Medium yield gap

Agro-geographic setting	Buldana	Akola
Climate	Hot moist semi arid	Hot moist semi arid
Soils	Vertic soils – 75%; Vertisols – 25%; Medium and deep clayey shallow black soils, loamy to clayey black soils	Vertic soils – 60%; Vertisols – 40%; Medium and deep clayey black shallow soils, loamy to clayey black soils
Annual rainfall (mm)	901	878
Potential evapotranspiration (mm)	1648	1730
Length of growing period (LGP) / moisture availability period (days)	120-150	120-150

Crop management

- **Varieties:** CSH –5, CSH-9, CSH-14, CSH-15, CSH-16, CSH-18, SPV-1616
- **Seed rate:** 10 kg/ha
- **Planting pattern:** 45 X 15 cm
- **Nutrient management** : 80 kg N + 40 kg P_2O_5 /ha + 6 t kg/ha FYM

Fig. 10. Trends in Area, Production and Productivity of Sorghum in Maharashtra (1980-2005)



Suitable cropping systems

- Sorghum– safflower
- Cotton + sorghum + pigeonpea + sorghum (CSH - 9) in 6:1:2:1 row ratio
- Sorghum + greengram in paired planting (30-60 cm)
- Sorghum + black gram in paired planting (30-60 cm)
- *kharif* sorghum or + pigeonpea in 6:1 proportion spaced at 45 cm rows
- Keep the sorghum field free of weeds by hoeing and weeding for the first 40 days after sowing

Farm implements / tools

Tools, implements	Operation
Manually operated fertilizer drill	Simple two row tool for top dressing (hand metered)
Bullock drawn serrated blade for interculture	Two rows, improved blades for intercultivation.

Alternate Farming Systems

- **Alley cropping:** Sorghum and *leucaena* in alley (9 m width)
- **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, Aindica, A.procera, Gliricidia*
- **Fruit:** Ber agro-horticulture system (Ber+short duration Legume crop) was found more remunerative than anola and custard apple horticulture system. Pomegranate Ber, Mango, Sapota, Guava, Tamarind
- **Medicinal & Aromatic Plants:** *Solanium viarum, Catharanthus roseus, Palma rosa, Vetiveria zyzanoides, Ocimum viride*
- **Vegetables:** Onion, Chilli, Brinjal, Okra, Amaranthus, Bottle gourd
- **Animal Component:** Female Cattle, Male Cattle, Female Buffaloes, Goat, Poultry

Contingent planning

- **Regular Monsoon :**

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

- **Light soils (depth 20 to 30-35 cm)**
  - Graded bunding of lands
  - Growing of strips of erosion resistant crops (Greengram-Kopergaon/blackgram-T-9) in the upper half of the plot and sorghum (CSH-9) in the lower half of the plot.
- **Medium deep soils (35-40 cm to 75 cm depth)**
  - Cotton AKH-84635 with greengram (Kopergaon) as an intercrop in 1:1 row ratio.
  - Sorghum CSH-9 with intercrop of greengram/ blackgram in 1:1 row ratio.
  - Groundnut intercropped with sunflower in the row ratio of 6:2 (Groundnut : JL-24, Sunflower-modern)

- **Deep soils (75 cm depth)**
  - Cotton – inter specific cultivation of Hirsutum Cotton AKA-7 with AKH-4 cotton.
  - Hybrid cotton AKH 4
  - Sorghum CSH-9/CSH-5 intercropped with pigeonpea (C-11) in 6:2 row ratio
- **Delayed onset of monsoon by 15 days:**

  If the rains start by end of June, the sowing may start in the first week of July. The following changes should be made in the cropping plans.
  - Area under cotton be reduced and replaced by sorghum.
  - Sowing of sorghum should be completed before 10th July. Sorghum CSH-1 variety be sown instead of CSH-5/CSH-9.
  - Area under greengram/ blackgram should be replaced by early pigeonpea varieties such as ICPL-8863 or ICPL-87119
  - Area under groundnut be reduced and replaced by sunflower (EC-68414)
- **Regular monsoon followed by long gaps:**
  - Wherever possible, life-saving irrigation be given.
  - Cotton can sustain some stress, but sorghum, groundnut, gram are not able to sustain such stress. Therefore, use of some conditioner such as spray of urea, not exceeding to 2 per cent concentration, may be useful.
  - If there is a total failure of crop, sowing of photo-insensitive crops such as bajra (BJ-104) or sunflower (EC-68414) may be attempted.
  - In deep soils, the land may be tilled properly, in case, kharif crop fails, to follow *rabi* crop safflower (N-7), pigeonpea (C-11) in September.
- **Continued monsoon**
- Advantage of this situation be exploited for double cropping with safflower and gram. Safflower (No.7) may be sown after sorghum till 15th October. Beyond 15th October gram may be sown.

State	District	Region
Maharashtra	Nanded and Latur (Central Maharashtra Plateau) Amravati and Yavatmal (Eastern Maharashtra Plateau) Wardha (Eastern Maharashtra Plateau, Maharashtra State)	Medium runoff and high yield gap

Agro-geographic setting	Nanded	Latur
Climate	Hot semi arid	Hot moist semi arid
Soils	Vertic soils – 60%; Vertisols – 40% Shallow and Medium loamy, medium and deep clayey black soils	Vertic soils – 100% Shallow and medium loamy black soils, deep clayey black soils
Annual rainfall (mm)	915	891
Potential evapotranspiration (mm)	1789	1861
Length of growing period (LGP) / moisture availability period (days)	120-150	90-150

Soil and water conservation

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

Crop management

- **Varieties :**
  - *Kharif* – CSV-15, SPV-1616, CSH-16, *Rabi* - CSV-18
  - M.35-1- Recommended for droughtprone area and medium deep soils.
  - Phule Yashoda - Recommended for deep soils
  - Mauli: Recommended for drought prone area & light soils
  - Sel. –3 : Recommended for light soils
  - Sweta, Swati : Deep soils
- **Seed rate:** 10 kg/ha
- **Planting Pattern:** 45 x 20 cm
- **Nutrient management :** 60 kg N + 30 kg P_2O_5 + 30 kg K_2O.

Farm Implements / tools

Tool/Implement	Cost	Operation carried
1) Tractor multicrop planter	Rs.22800/-	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.
2) Bullock drawn Jyoti Planter.	Rs.7500/-	The field trials were conducted and the machine is recommended for sowing the crops of dryland region.
3) Weeders developed by Maharashtra Agro Industries Development Corporation Ltd. (MAIDC)	Rs.410/-	These weeders were tested on farmer's field and identified for weeding and interculturing in row crops.
4) Tractor drawn a) Single bottom reversible plough. b) Double bottom reversible plough.	 Rs.18500/- Rs.23600/-	Tested on farmers' field for ploughing and identified for ploughing operations in dryland region as the field operation was effective and economical.
5) Bund former	Rs.1050/-	Bund formers were tested and found suitable for compartmental bunding.
6) Baliram plough	Rs.2500/-	Identified for moisture conervation practices like ridges and furrows and compartmental bunding.
7) Kopergaon bullock drawn two bowl seed drill.	Rs.9000/-	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.

Alternate Farming Systems

- **Silvipasture:** *Leucaena* + Marvel –8
- **Alley cropping:** Ber (20 m alleys) + pearlmillet + pigeonpea for shallow soils
- **Fodder:** Maize (African Tall) Oats (Kent), Stylo hamata
- **Fodder/ green biomass:** *Dalbizia sissoo, Albizzia lebbeck, Anogeissus latfolia, Sesbania Stylo Marvel – 8 grass*
- **Fruit:** Ber, custard apple, pomegranate, amla+kharif spreadingcrops
- **Medicinal/ Aromatic Plants:** *Catharanthus roseus, Palma rosa, Vetiveria zyzanoides, Rose Geranium*
- **Vegetables:** Onion, Tomato, Okra, Cowpea, Cluster bean, Drumstick
- **Animal Component:**
- Cow breeds: Gir, Jersey, HF
- Poultry : White Leghorn
- Rams
- Male/ female cattle, female buffaloes, sheep, goat

Alternate Land Use Systems

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

Contingent Planning

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

2nd Fortnight of June	All *kharif* crops
1st 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)
2nd Fortnight of July	Sunflower, Pigeonpea, Horsegram, Setaria, Castor, Pearlmillet (ergot resistant), Intercropping of Sunflower + pigeonpea (2:1)

1st Fortnight of August	Sunflower, Pigeonpea, Castor, Horsegram Sunflower + pigeonpea (2:1)
2nd Fortnight of August	Sunflower, Pigeonpea, Castor Sunflower + pigeonpea (2:1)
1st Fortnight of September	Sorghum for fodder
2nd Fortnight of September	*Rabi* Sorghum, Safflower, Sunflower
1st Fortnight of October	*Rabi* Sorghum, Safflower, Chickpea, Sunflower
2nd Fortnight of October	Chickpea, Sunflowewr, *Rabi* Sorghum.
1st Fortnight of November	Chickpea, Sunflower.

Agro-geographic setting	Amravati	Yavatmal
Climate	Hot moist semi arid	Hot moist semi arid
Soils	Vertic soils – 85%; Vertisols– 15%; Medium and deep clayey black soils, shallow loamy to clayey black soils	Vertic soils – 100% Medium and deep clayey black soils, shallow loamy to clayey black soils
Annual rainfall (mm)	976	1133
Potential evapotranspiration (mm)	1770	1775
Length of growing period (LGP) / moisture availability period (days)	120-150	120-150

Soil and water conservation

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

Crop management

- **Varieties :** CSH –5, CSH-9, SPV-102, CSH-14, CSV-15, CSH-16, SPV-1616
- **Seed rate:** 10 kg/ha
- **Planting Pattern:** 45 X 15 cm
- **Nutrient management :** 80 kg N + 40 kg P_2O_5.

Suitable cropping systems

- Sorghum– safflower
- Cotton + sorghum + pigeonpea + sorghum in 6:1:2:1 row ratio
- Sorghum + greengram in paired planting (30-60 cm)

- Sorghum + black gram in paired planting (30-60 cm)
- Sorghum + pigeonpea in 6:1 proportion spaced at 45 cm rows
- Sorghum (fodder) + chickpea
- Keep the sorghum field free of weeds by hoeing and weeding for the first 40 days after sowing

Farm implements / tools

Tools, implements	Operation
Manually operated fertilizer drill	Simple two row tool for top dressing (hand metered)
Bullock drawn serrated blade for interculture	Two rows, improved blades for intercultivation.

Alternate Farming Systems

- **Alley cropping :** Sorghum and *leucaena* in alley (9 m width)
- **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, Aindica, A.procera, Gliricidia*
- **Fruit:** Ber agro-horticulture system (Ber+short duration Legume crop) was found more remunerative than anola and custard apple horticulture system.
- Pomegranate Ber, Mango, Sapota, Guava, Tamarind
- **Medicinal & Aromatic Plants:** *Solanum viarum, Catharanthus roseus, Palma rosa, Vetiveria zyzanoides, Ocimum viride*
- **Vegetables:** Onion, Chilli, Brinjal, Okra, Amaranth, Bottle-gourd
- **Animal Component:** Female Cattle, Male Cattle, Female Buffaloes, Goat, Poultry

Contingent planning

- **Regular Monsoon**

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

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

- Sorghum CSH-9/CSH-5 intercropped with pigeonpea (C-11) in 6:2 row ratio

- **Delayed onset of monsoon by 15 days:**
  - If the rains start by end of June, the sowing may start in the first week of July. The following changes should be made in the cropping plans.
  - Area under cotton be reduced and replaced by sorghum.
  - Sowing of sorghum should be completed before 10th July. Sorghum CSH-1 variety be sown instead of CSH-5/CSH-9.
  - Area under greengram/ blackgram should be replaced by early pigeonpea varieties such as ICPL-8863 or ICPL-87119
  - Area under groundnut be reduced and replaced by sunflower (EC 68414)
- **Regular monsoon followed by long gaps:**
  - Wherever possible, life-saving irrigation be given.
  - Cotton can sustain some stress, but sorghum, groundnut, chickpea are not able to sustain such stress. Therefore, use of some conditioner such as spray of urea, not exceeding to 2 per cent concentration, may be useful.
  - If there is a total failure of crop, sowing of photo-insensitive crops such as bajra (BJ-104) or sunflower (EC-68414) may be attempted.
  - In deep soils, the land may be tilled properly, in case, kharif crop fails, to follow *rabi* crop safflower (N-7), pigeonpea (C-11) in September.
- **Continued monsoon**
  - Advantage of this situation be 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.

Agro-geographic setting	Wardha
Climate	Hot dry sub humid
Soils	Vertic soils – 100%
	Shallow and medium loamy to clayey black soils, deep clayey black soils
Annual rainfall (mm)	1144
Potential evapotranspiration (mm)	1788
Length of growing period (LGP) / moisture availability period (days)	150-180

Soil and water conservation

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

Crop management

- **Varieties :** CSH –5, CSH-9, SPV-102
- **Seed rate;** 10 kg/ha
- **Planting Pattern:** 45 X 15 cm
- **Nutrient management :** 80 kg N + 40 kg P_2O_5.

Suitable cropping systems

- Sorghum– safflower
- Cotton + sorghum + pigeonpea + sorghum in 6:1:2:1 row ratio
- Sorghum + greengram in paired planting (30-60 cm)
- Sorghum + black gram in paired planting (30-60 cm)
- Sorghum + pigeonpea in 6:1 proportion spaced at 45 cm rows
- Sorghum (fodder) + chickpea
- Keep the sorghum field free of weeds by hoeing and weeding for the first 40 days after sowing

Farm implements / tools

Tools, implements	Operation
Manually operated fertilizer drill	Simple two row tool for top dressing (hand metered)
Bullock drawn serrated blade for interculture	Two rows, improved blades for intercultivation.

Alternate Farming Systems

- **Alley cropping :** Sorghum and *leucaena* in Alley (9 m width)
- **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*
- **Fruit:** Ber agro-horticulture system (ber+short duration Legume crop) was found more remunerative than anola and custard apple horticulture system, Pomegranate Ber, Mango, Sapota, Guava, Tamarind
- **Medicinal & Aromatic Plants:** *Solanum viarum, Catharanthus roseus, Palma rosa, Vetiveria zyzanoides, Ocimum viride*
- **Vegetables:** Onion, Chilli, Brinjal, Okra, Amaranthus, Bottle-gourd
- **Animal Component:** Female Cattle, Male Cattle, Female Buffaloes, Goat, Poultry

Contingent planning

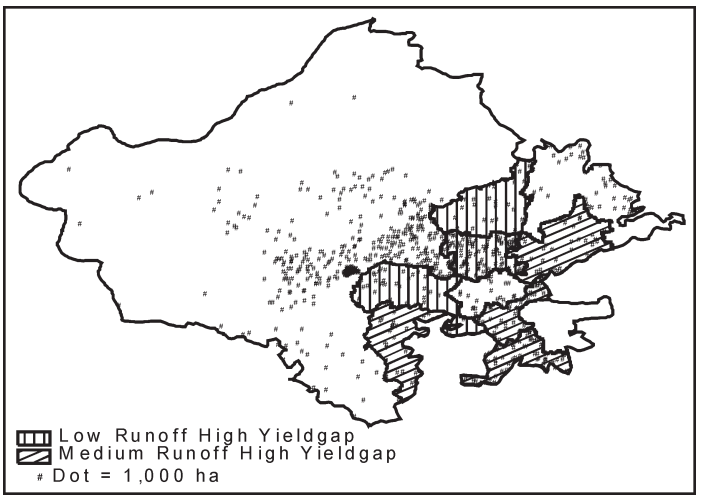
- **Regular Monsoon**
- The regular monsoon starts by 24th meteorological week. For regular monsoon the following recommendations stand.
- **Light soils (depth 20 to 30-35 cm)**
    - Graded bunding of lands

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

- **Medium deep soils (35-40 cm to 75 cm depth)**
  - Cotton AKH-84635 with greengram (Kopergaon) as an intercrop in 1:1 row ratio.
  - Sorghum CSH-9 with intercrop of greengram/ blackgram in 1:1 row ratio.
  - Groundnut intercropped with sunflower in the row ratio of 6:2 (Groundnut : JL-24, Sunflower-morden)
- **Deep soils (75cm depth)**
  - Cotton – inter specific cultivation of *Hirsutum* Cotton AKA-7 with AKH-4 cotton.
  - Hybrid cotton AKH-4
  - Sorghum CSH-9/CSH-5 intercropped with pigeonpea (C-11) in 6:2 row ratio
- **Delayed onset of monsoon by 15 days:**
  - If the rains start by end of June, the sowing may start in the first week of July. The following changes should be made in the cropping plans.
  - Area under cotton be reduced and replaced by sorghum.
  - Sowing of sorghum should be completed before 10th July. Sorghum CSH-1 variety be sown instead of CSH-5/CSH-9.
  - Area under greengram/ blackgram should be replaced by early pigeonpea varieties such as ICPL-8863 or ICPL-87119
  - Area under groundnut be reduced and replaced by sunflower (EC-68414)
- **Regular monsoon followed by long gaps:**
  - Wherever possible, life-saving irrigation be given.
  - Cotton can sustain some stress, but sorghum, groundnut, chickpea are not able to sustain such stress. Therefore, use of some conditioner such as spray of urea, not exceeding to 2 per cent concentration, may be useful.
  - If there is a total failure of crop, sowing of photo-insensitive crops such as bajra (BJ-104) or sunflower (EC-68414) may be attempted.
  - In deep soils, the land may be tilled properly, in case, kharif crop fails, to follow *rabi* crop safflower (N-7), pigeonpea (C-11) in September.
- **Continued monsoon**
  - Advantage of this situation be exploited for double cropping with safflower and chickpea. Safflower (No.7) may be sown after sorghum till 15th October. Beyond 15th October chickpea may be sown.

RAJASTHAN

In Rajasthan there are three districts viz. Bhilwara, Tonk and Jaipur under low runoff and high yield gap region and four districts viz. Sawaimadhopur, Kota, Jalawar and Chittorgarh under medium runoff and high yield gap region. The trends in area, production and productivity of sorghum in Rajasthan (1980 - 2005) are shown in Fig. 11.



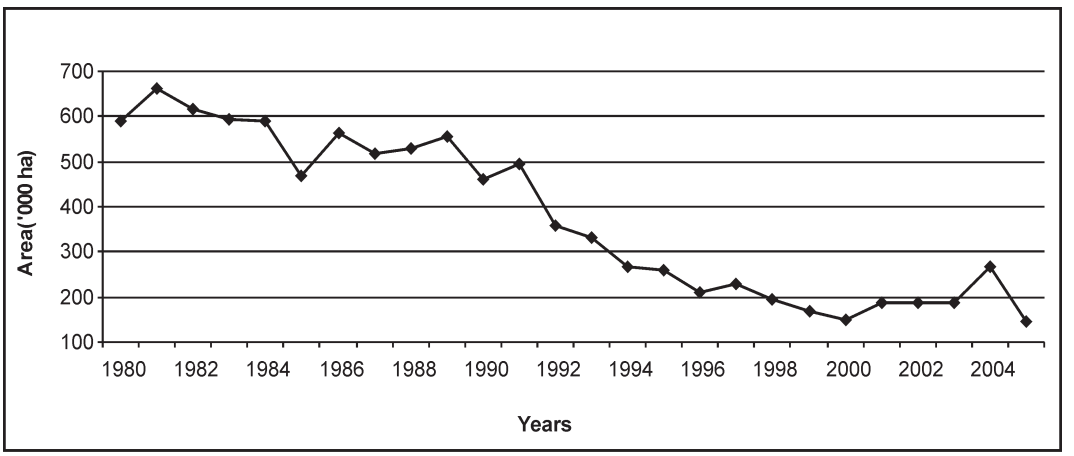
State	District	Region
Rajasthan	Bhilwara (East Rajastan Uplands) Tonk and Jaipur (Central East Rajasthan)	Low runoff and High yield gap

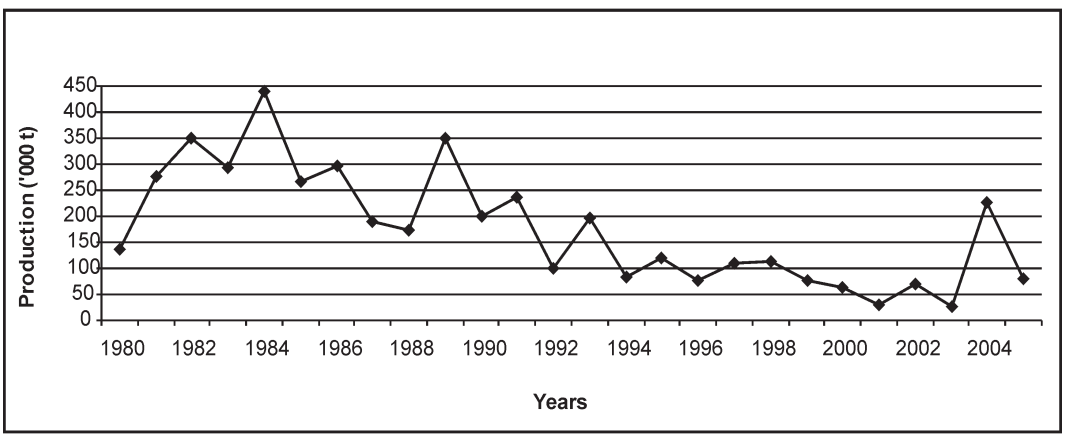
Agro-geographic setting	Bhilwara	Tonk	Jaipur
Climate	Hot dry semi arid	Hot dry semi arid	Hot semi arid
Soils	Vertic soils – 100% Deep loamy grey brown and alluvium - derived soils	Inceptisols – 100% Deep loamy grey brown and alluvium - derived soils	Inceptisols – 100%, Deep loamy alluvium - derived soils
Annual rainfall (mm)	658	703	647
Potential evapotranspiration (mm)	1559	1597	1745
Length of growing period (LGP) / moisture availability period (days)	90-120	90-120	90-120

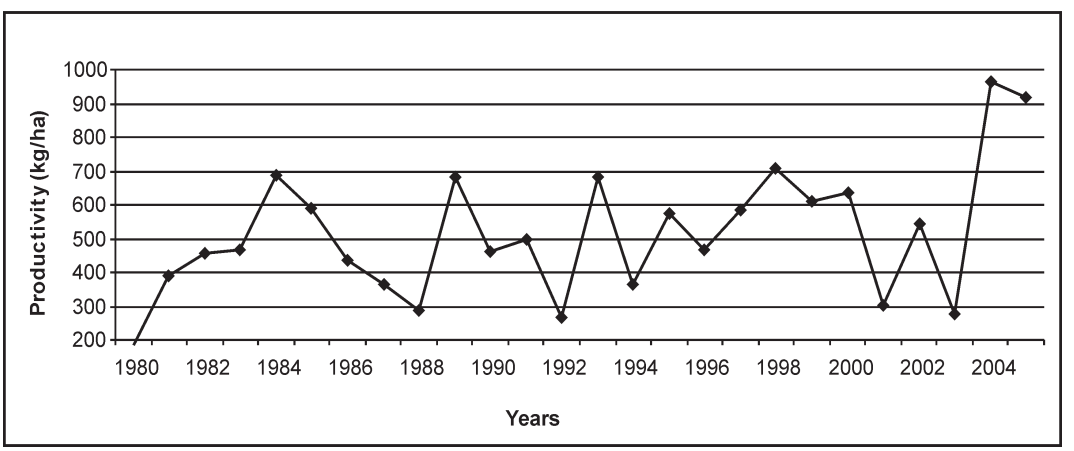
Soil and water conservation

- More emphasis on *in situ* water conservation
- Increasing soil infiltration capacity and reducing soil crusting problem
- Contour furrowing
- Absorption terracing
- Contour trenches

Fig. 11. Trends in Area, Production and Productivity of Sorghum in Rajasthan (1980-2005)







- Inter-row water harvesting
- Inter-plot water harvesting of 1:1 cropped to un-cropped land
- Dead furrows at 3.6 m interval
- Indigenous Water harvesting structures

Crop management

- **Varieties :** CSH-6, CSH-14, SPV-245, GJ-38, SPV-1736

  Fodder – GFS -4
- **Seed rate** : 10 kg/ha
- **Planting Pattern:** 45 cm rows
- **Nutrient management :** 50 kg N + 30 kg P_2O_5. N in 2 splits ½ as basal and ½ at knee high stage

Suitable cropping systems

- Sorghum / maize-mustard
- Sorghum fodder - mustard

Farm implements / tools

- Two bowl seed cum fertilizer drill

Alternate Farming Systems

- **Marginal lands :**
- **Silviculture:** *Acacia tortilis*
- **LCC III :** Alley cropping (Jatropha spp + Greengram)
- **LCC IV :** Silvipastoral system (*Prosopis cineraria* + *Cenchrus*)
- **Horti – Pastoral system:** Ber + *Cenchrus setigerus*
- **Fodder/ green biomass:** *Ailanthus excelsa, Albizzia lebbeck, D. sissoo, Azadirachta indica, Prosophis cineraria, Dichrostachys*
- Fruit: Ber, Date palm, Jamun, Fig. Phalsa, Koronda
- **Medicinal/ Aromatic Plants:** *Plantago ovata, Cassia angustifolia, Safed musli, Papaver somniferum*
- **Vegetables:** Cluster bean, Cowpea, Amaranth, Round melon, Long melon
- **Animal Component:** Male/female cattle, female buffaloes, sheep, goat

Contingent Planning

- **Good and normal rainfall**

  Grow large areas under improved varieties of cereals, pulses and oilseeds during kharif on heavy soils, conserve soil moisture during kharif and take 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 / pigeon pea, groundnut + sesame is recommended

- **Early withdrawal of monsoon :**

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

State	District	Region
Rajasthan	Sawaimadopur (Central East Rajasthan Uplands) Kota and Jhalawar (South East Rajasthan) Chittorgarh (Southern Rajasthan)	Medium runoff and High yield gap

Agro-geographic setting	Sawaimadopur	Kota	Jhalawar	Chittorgarh
Climate	Hot semi arid	Hot moist semi arid	Hot moist semi arid	Hot dry semi arid Hot moist semi arid
Soils	Vertic soils – 85%; Inceptisols – 15% Deep loamy alluvium - derived soils	Vertic soils – 100% Deep clayey black soils, shallow black soils	Vertic soils – 100% Deep clayey black soils, shallow black soils	Vertic soils – 100% Deep loamy grey brown and alluvium- derived soils Deep clayey black soils, shallow black soils
Annual rainfall (mm)	753	842	1024	885
Potential evapotranspiration (mm)	1569	1523	1557	1556
Length of growing period (LGP) / moisture availability period (days)	90-12	120-150	120-150	90-150

Soil and water conservation

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

Crop management

- **Varieties :** CSH-6, CSH-14, SPV-1736
- **Seed rate :** 10 kg/ha

- **Planting Pattern:** 45 cm rows
- **Nutrient management :** 50 kg N + 30 kg P_2O_5. N in 2 splits ½ as basal and ½ at knee high stage

Suitable cropping systems

- Sorghum / maize-mustard
- Sorghum fodder - mustard

Farm implements / tools

- Two bowl seed cum fertilizer drill

Alternate Farming Systems

- **Marginal lands :**
- **Silviculture:** *Acacia tortilis*
- **LCC III :** Alley cropping (Jatropha spp + Greengram)
- **LCC IV :** Silvipastoral system (*Prosopis cineraria* + *Cenchrus*)
- **Horti – Pastoral system:** Ber + *Cenchrus setigerus*
- **Fodder/ green biomass:** *Ailanthus excelsa, Albizzia lebbeck, Dalbizia sissoo, Azadirachta indica, Prosophis cineraria, Dichrostachys*
- **Fruit:** Ber, Date palm, Jamun, Fig. Phalsa, Koronda
- **Medicinal/ Aromatic Plants:** *Plantago ovata, Cassia angustifolia, Safed musli, Papaver somniferum*
- **Vegetables:** Clusternbean, Cowpea, Amaranthus, Round melon, Long melon
- **Animal Component:** Male/female cattle, female buffaloes, sheep, goat

Contingent Planning

- **Good and normal rainfall :**

  Grow large areas under improved varieties of cereals, pulses and oilseeds during kharif on heavy soils, conserve soil moisture during kharif and take 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 :**

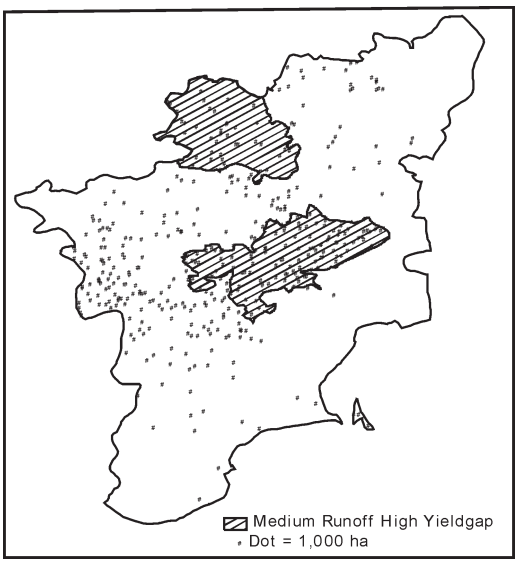
  Grow early maturing pulses (greengram blackgram), oilseeds (sesame) and fodder crops (sorghum + cowpea). Intercropping of maize + blackgram / pigeon pea, groundnut + sesame is recommended

- **Early withdrawal of monsoon :**

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

TAMIL NADU

In Tamil Nadu there are two districts viz. Tiruchirapalli and Dharmapuri under medium runoff and high yield gap region. The trends in area, production and productivity of sorghum in Tamil Nadu (1980 - 2005) are shown in Fig. 12.



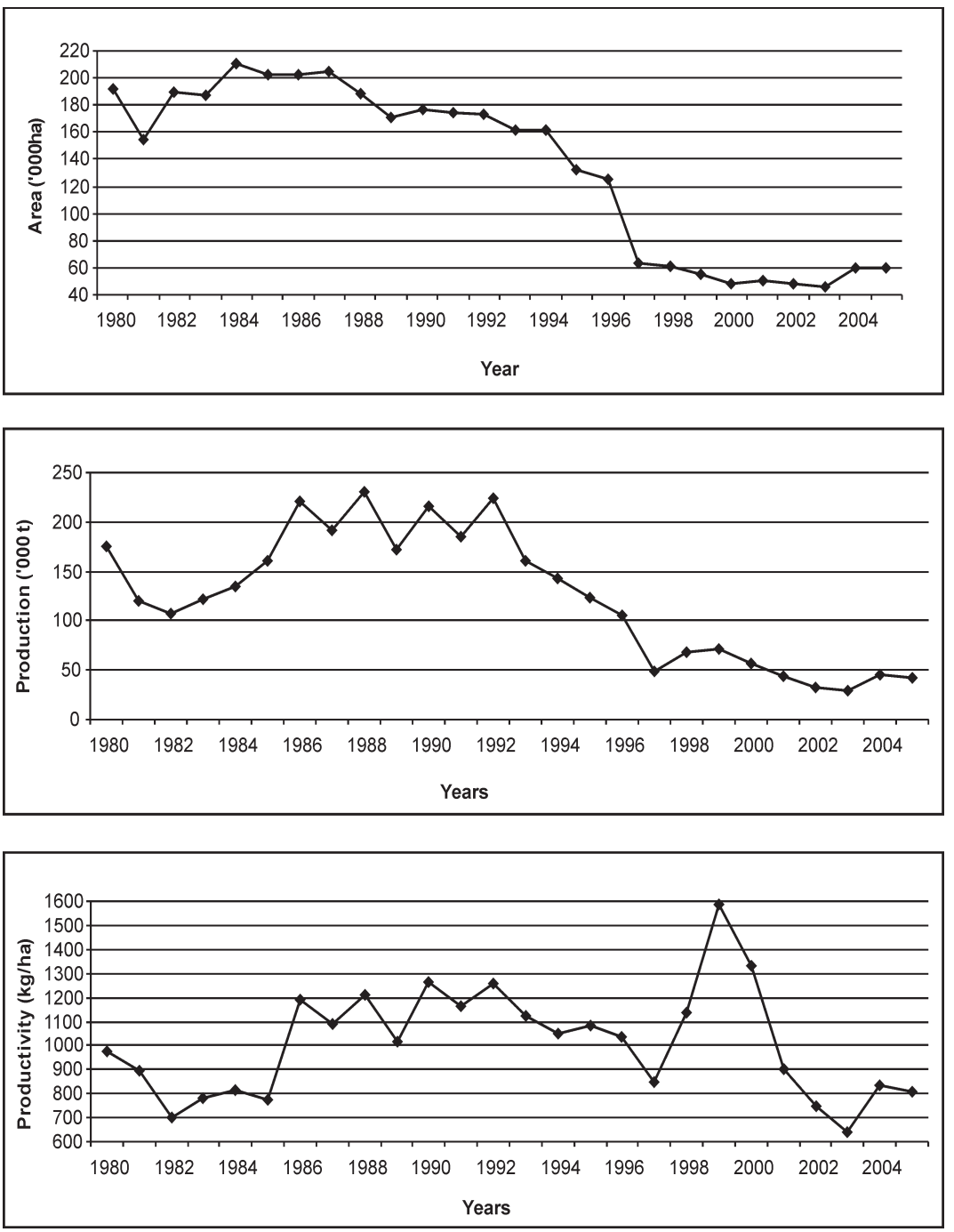
State	District	Region
Tamil Nadu	Tiruchirapalli (Tamil Nadu Uplands) Dharmapuri (Western plains)	Medium runoff and High yield gap

Agro-geographic setting	Tiruchirapalli	Dharmapuri
Climate	Hot moist semi arid	Hot moist semi arid
Soils	Orthids – 25%; Sandy Alfisol – 75% Deep red loamy soils	Sandy Alfisols – 100%, Deep red loamy soils
Annual rainfall (mm)	869	876
Potential evapotranspiration (mm)	2091	1651
Length of growing period (LGP) / moisture availability period (days)	120-150	120-150

Soil and water conservation

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

Fig. 12. Trends in Area, Production and Productivity of Sorghum in Tamilnadu (1980-2005)



- Absorption/drainage type terraces
- On sloppy land contour cultivation along vegetative hedge of Vetiver or *Leucaena* at 0.5 m V.I. in sorghum and cotton crops.

Crop management

- **Varieties :** K-Tall, K-8, K-3 for fodder
- **Seed rate:** 10 kg/ha
- **Planting Pattern:** 45 x 15 cm
- **Nutrient management:** 40 kg N + 20 kg P_2O_5 as enriched FYM

Suitable cropping systems

- Sorghum + blackgram
- Sorghum + cowpea
- Sorghum + greengram
- Sorghum + siratro (fodder) (1:1)
- **Some other important practices**
  - Deep ploughing with mould board plough
  - Dibbling with compaction

Alternate Farming Systems

- **Alley cropping:** Subabul(6 m width) + Sorghum/ Pearlmillet/ Pigeonpea, Subabul (6 m width) + mulching with Subabul leaves in alleys + Cotton/blackgram/Sunflower
- **Agroforestry :** Tamarind/Neem + Sorghum (K-8), Tamarind/Neem + blackgram (C0-5)
- **Agro-horti system :** Tamarind (PKM-1) + blackgram (K-1)
- **Silvipasture:** *Ailanthus excelsa* + blackgram, *Ailanthus excelsa* + Dinanath grass
- **Fodder/ green biomass:** *Alianthas excelsa, Albizzia lebbeck,Leucaena leuecocephala Hardwickia binata, A.indica*
- **Fruit:** Mango, Sapota, Fig, Jamun, Pomegranate
- **Medicinal/ Aromatic Plants:** *Cassia aungstifolia, Palma rosa, Vetiveria zyzanoides, Jasmine, Rose geranium*
- **Vegetables:** Okra, Bittergourd, Ridge gourd, Chilles, Brinjal, Amaranthus.
- **Animal Component:** Sheep, Goat

Integrated Farming System

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

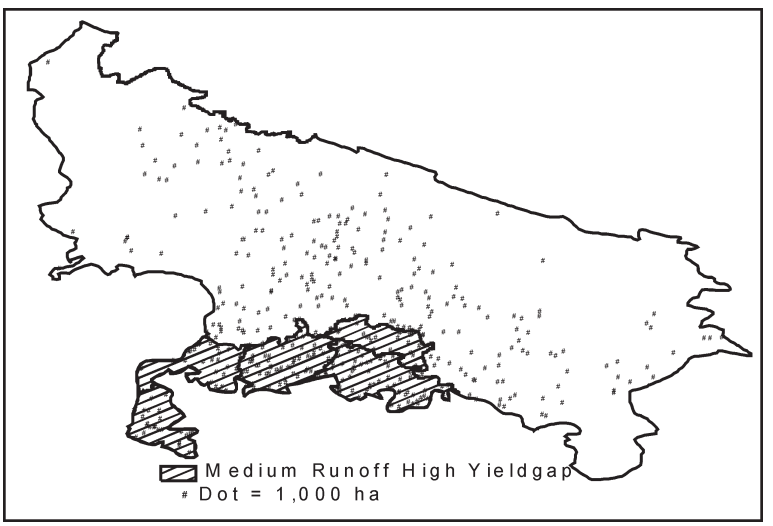
Contingent planning

- Normal monsoon conditions: With the onset of North-East monsoon in September – October, crops like sorghum, cotton, bajra, pulses and oilseeds can be sown. Sorghum (K.Tall or K-8) may be sown during the month of September
- Delayed onset of monsoon : If the rains the received late in October, bajra (WCC75) can be sown. Pulses like blackgram, greengram, and oilseeds like sunflower (K-1) can be grown if the rains are received later.
- Very delayed monsoon: Sunflower (K-1), Gingelly (TMV-3), Senna and Coriander can be sown upto the first week of November under very delayed monsoon conditions.
- Early withdrawal of monsoon: Short duration crops like bajra (Co.6 and X 4) with 75 days duration and sunflower (K-1) with 65 days duration are grown.

Cultural practices like shallow intercultural to eradicate weeds, maintain soil mulch to conserve soil moisture, application of surface mulch, thinning of crops by removing alternate rows as in bajra and recycling of stored runoff

UTTAR PRADESH

In Uttar Pradesh there are five districts viz. Fatehpur, Banda, Hamirpur, Jhansi and Lalitpur under medium runoff and high yield gap region. The trends in area, production and productivity of sorghum in Uttar Pradesh (1980 - 2005) are shown in Fig. 13.



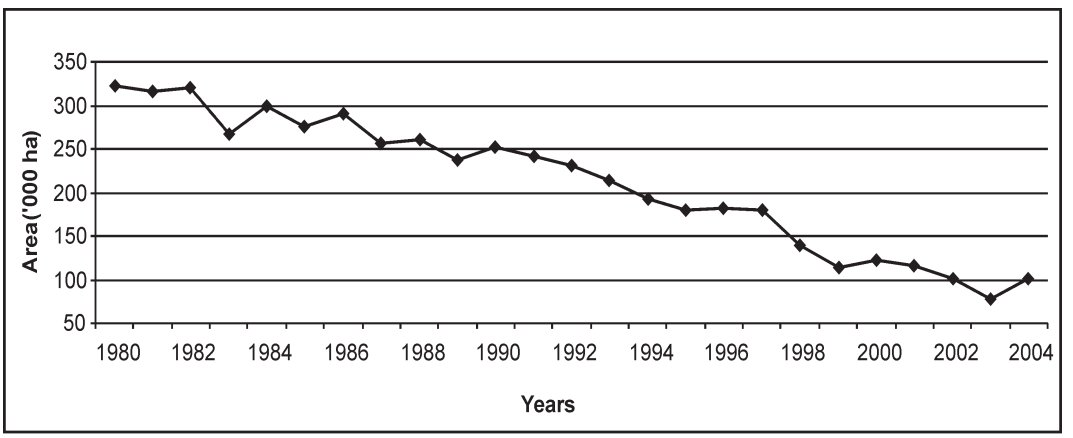
State	District	Region
Uttar Pradesh	Fatehpur (Ganga – Yamuna Doab)	Medium runoff and
	Banda, Hamirpur, Jhansi and Lalitpur (Bundlekhand uplands)	High yield gap

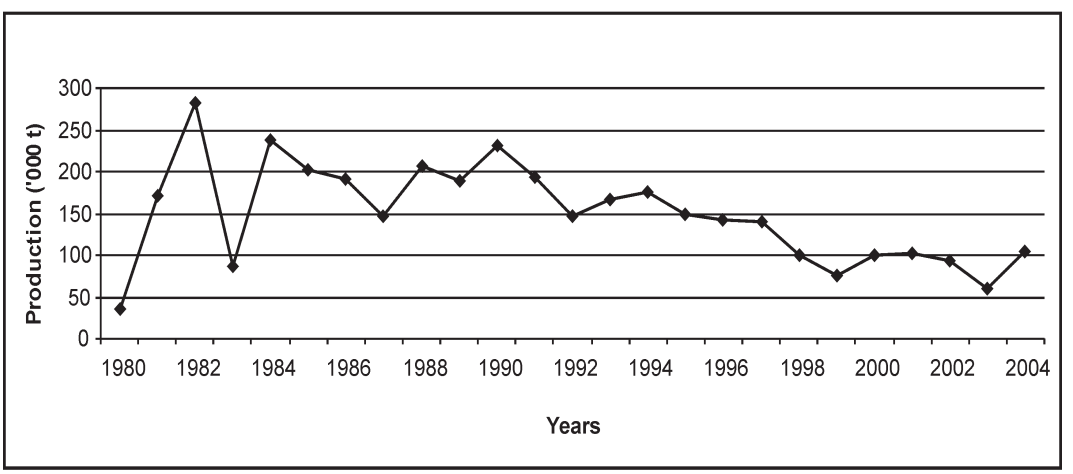
Agro-geographic setting	Fatehpur	Banda	Hamirpur	Jhansi	Lalitpur
Climate	Hot moist semi arid	Hot moist semi arid	Hot moist semi arid	Hot moist semi arid	Hot moist semi arid
Soils	Inceptisols–100%, Deep loamy alluvium - derived soils	Inceptisols–100%, Deep loamy and clayey mixed red and black soils	Inceptisols–100%, Deep loamy and clayey mixed red and black soils	Inceptisols–100%, Deep loamy and clayey mixed red and black soils	Inceptisols–100%, Deep loamy and clayey mixed red and black soils
Annual rainfall (mm)	885	1005	998	999	804
Potential evapotranspiration(mm)	1464	1455	1481	1516	1489
Length of growing period (LGP) / moisture availability period (days)	120-150	120-150	120-150	120-150	120-150

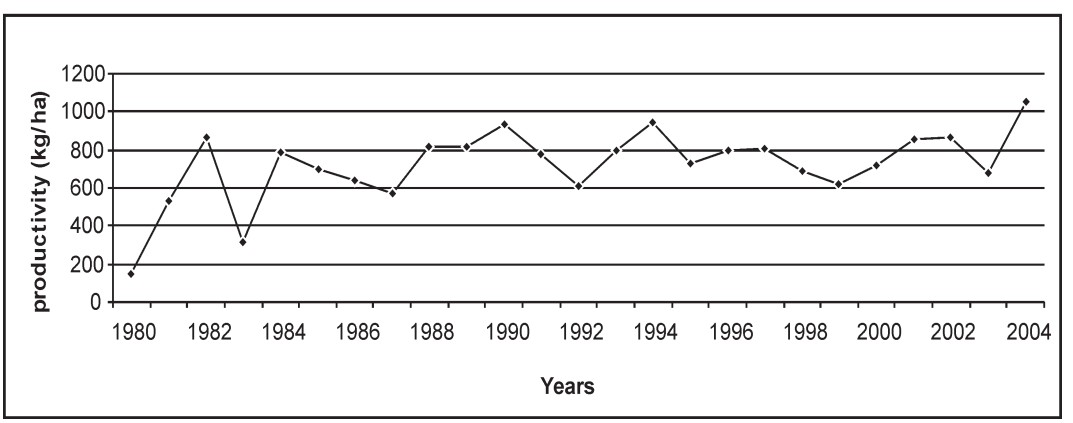
Soil and water conservation

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

Fig. 13. Trends in Area, Production and Productivity of Sorghum in Uttar Pradesh (1980-2005)







Crop management

- **Varieties :** CSH-15, SPV-1616
- **Seed rate:** 5 –6 kg/ha (Hybrid), 10 kg/ha (Varieties)
- **Planting Pattern:** 45 x 15 –20 cm
- **Integrated Nutrient Management :**
- 80 kg N + 40 kg P_2O_5/ha + FYM @ 6t/ha + 3 tonnes of subabul/ha + 30 kg N + 20 kg P_2O_5/ha

Suitable cropping systems

- Sorghum + pigeonpea (2: 1)
- Sorghum - chickpea
- Fodder sorghum – safflower
- Fodder sorghum – chickpea/lentil/mustard/ for black soils

Farm implements / tools

- Dryland weeder
- Seed cum ferti drill

Alternate Farming Systems

- Ley farming Four year continuum raising of stylosanthes harmeta – sorghum
- Forage Sorghum – safflower
- Forage Sorghum – chickpea / lentil / mustard
- Fodder cowpea / sesbania + grain sorghum
- Pigeonpea + Forage sorghum / Teosinte / Maize / Pearlmillet / Sudan grass/ Cowpea / Cluster bean / Sunhemp
- **Fodder/ green biomass:** *Leucaena, Melia azadirach, Dichro stachys cineraria, Albizzia amara, A.lebbeck, Hardwickia binata, A.nilotica*
- **Fruit:** Emblica officinalis {amla] , Guava, Ber, Mango
- **Medicinal/ Aromatic Plants:** *Rauvolfia serpentina, Vetivera zyzanoides, Palma rosa, Safed musli, Aswagandha.*
- **Vegetables**: Bottle gourd, Brinjal, Tomato, Chillies, Brinjal, Cowpea, Okra
- **Animal Component:** Female Cattle, Male Cattle, Female Buffaloes, Goat, Poultry

Prioritised cultural option for rainfed sorghum based production system

State	District	Prioritised Options	Average Yield	Expeceted Yield
Gujarat	Ahmedabad, Amreli, Bhavnagar, Mehsana, Surendran, Rohtak	Adoption of improved varieties, crop management technologies. *In-situ* soil conservation measures.	268	322 to 335
Karnataka	Mysore	Utilization of surplus water for supplemental irrigation and adoption of high yield cultivars	1019	1223 to 1274
Madhya Pradesh	Betul, Chhatapur, Dhar, Guna, Jabhua, Khandwa, Mandsaur, Shivpuri	Utilization of surplus water for supplemental irrigation and adoption of high yield cultivars	667	800 to 834
	Dewas	Utilization of surplus water for supplemental irrigation and adoption of high yield cultivars	1307	1568 to 1634
	Chhindwar, Khargone, Ratlam, Shajapur, Ujjain	Utilization of surplus water for supplemental irrigation and adoption of high yield cultivars	1019	1223 to 1274
Maharastra	Amravathi, Latur, Nanded, Yeotmal	Utilization of surplus water for supplemental irrigation and adoption of high yield cultivars	1307	1568 to 1634
	Wardha	Utilization of surplus water for supplemental irrigation and adoption of high yield cultivars	1019	1223 to 1274
	Akola, Buldhana	Water management technologies and adoption of improved cultivars and pest and disease management packages for improving productivity	1660	1909 to 1992
Rajasthan	Bhilwara, Jaipur, Tonk		268	322 to 335
	Chittorga, Jhalawar, Kota, Sawai Madopur	Utilization of surplus water for supplemental irrigation and adoption of high yield cultivars	667	800 to 834
Tamilnadu	Dharmapur	Utilization of surplus water for supplemental irrigation and adoption of high yield cultivars	1307	1568 to 1634
	Tiruchirapalli	Utilization of surplus water for supplemental irrigation and adoption of high yield cultivars	1019	1223 to 1274
Uttar Pradesh	Banda, Hamirpur, Jhansi, Lalitpur	Utilization of surplus water for supplemental irrigation and adoption of high yield cultivars		
	Fatepur	Utilization of surplus water for supplemental irrigation and adoption of high yield cultivars		

PEARLMILLET BASED PRODUCTION SYSTEM

Pearlmillet is grown in 10.50 m ha in 346 districts out of which 9.90 m ha is rainfed. About 85% of the rainfed area (4.35 mha) is in 43 districts.

Selection criteria	No. of districts	Area under pearlmillet ('000 ha)	Area under rainfed pearlmillet ('000 ha)	Gross cropped area ('000 ha)	Yield (kg/ha)
Rainfed states (13)	346	10494	9898	167868	613
AESR 3-13	261	5553	5153	131273	673
Cumulative 85% rainfed pearlmillet area	43	4610	4350	30595	875

Growth Rates

The trends in area, production and productivity of pearlmillet in India (1980 - 2005) are shown in Fig. 14.

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

Area	Yield	State	District
Stagnant	Increasing	Madhya Pradesh Maharastra Uttar Pradesh	Morena Pune, Jalgaon, Satara, Sangli Aligarh, Etawah
Stagnant	Stagnant	Gujarat Karnataka Maharastra Rajasthan Tamilnadu Uttar Pradesh	Rajkot, Ahmedabad, Junagadh Raichur Nasik, Ahmednagar Alwar, Sawai Madhopur South Arcot Moradabad
Decreasing	Stagnant	Gujarat Haryana Karnataka Rajasthan Tamilnadu	Bhavnagar, Amreli Gurgaon Gulbarga, Belgaum Bharatpur Tiruchinapalli
Increasing	Stagnant	Gujarat Maharastra Uttar Pradesh	Surendranagar Aurangabad, Beed, Dhule Baduan
Increasing	Increasing	Rajasthan	Jaipur
Decreasing	Increasing	Karnataka Uttar Pradesh	Bijapur Agra, Etawah, Mathura, Allahabad

The yield growth rate was significantly raising in Morena, Bijapur, Jalgaon, Pune, Satara, Sangli, Jaipur, Aligarh, Mathura, Etawah, Allahabad and Etah districts. The area growth rate is significantly increasing in Dhule, Aurangabad, Beed, Surendranagar, Jaipur and Baduan districts. The area growth rate is significantly decreasing in Belgaum, Bijapur, Gulbarga, Tiruchinapalli, Amreli, Bharatpur, Gurgaon, Mathura, Agra, Etah and Allahabad districts.

Popular Production Systems in Agro-ecozones

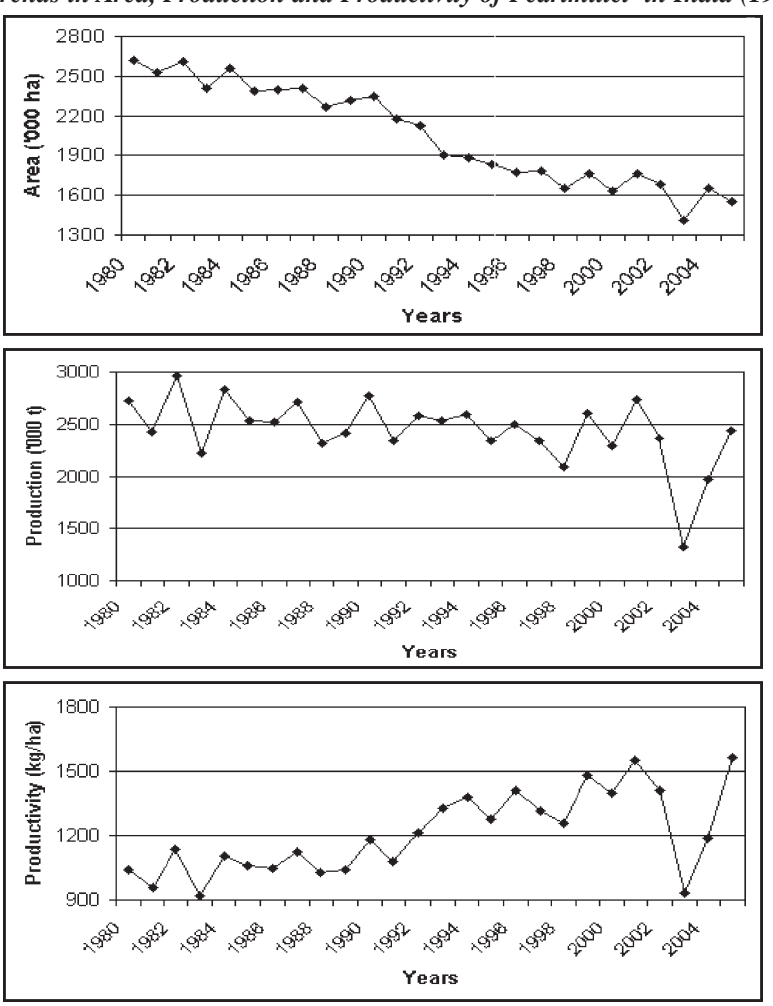
Pearlmillet	AER
Pearlmillet + Pigeonpea Pearlmillet –Fallow/Wheat/ Chickpea	3
Tobacco – Pearlmillet Pearlmillet- Fallow/ Chickpea	4
Pearlmillet + Pigeonpea Pearlmillet+ Greengram	6

Farming systems

Details on associated crops and districts covered and spread of livestock population are presented below:

Crops	Animals	Districts
Sorghum Pearlmillet Groundnut Cotton Vegetables Fruits	Goats Male Cattle Female cattle Female Buffalo Male Buffalo	Morena, Belgaum Bijapur, Raichur, Gulbarga, South Arcot, Tiruchinapalli, Nasik, Dhule, Jalagaon, Ahmednagar, Pune, Satara, Sangli, Aurangabad, Beed, Ahmedabad, Amreli, Bhavnagar, Junagadh, Rajkot, Surendranagar, Sawaimadhopur, Jalna, Villupuram
Pearlmillet Rapeseed mustard Chickpea Fruits Vegetables	Female Buffalo Goats Male Cattle Female Cattle Male Buffalo	Alwar, Jaipur, Bharatpur, Gurgaon, Aligarh, Mathura, Agra, Etah, Buduan, Moradabad, Etawah, Allahabad, Dholpur, Ferozbad, Dausa

Fig. 14. Trends in Area, Production and Productivity of Pearlmillet in India (1980-2005)



GUJARAT

In Gujarat there are three districts viz. Amreli, Bhavnagar and Junagadh under low runoff and medium yield gap region and three districts viz. Ahmedabad, Surendranagar and Rajkot under low runoff and high yield gap region. The trends in area, production and productivity of pearlmillet in Gujarat (1980 - 2005) are shown in Fig. 15.

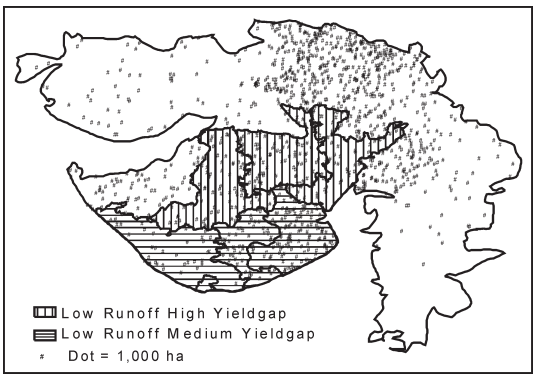
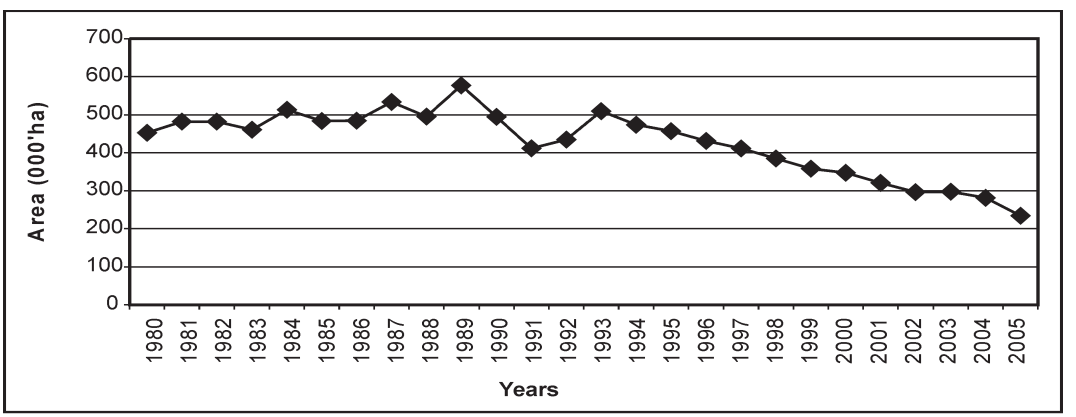
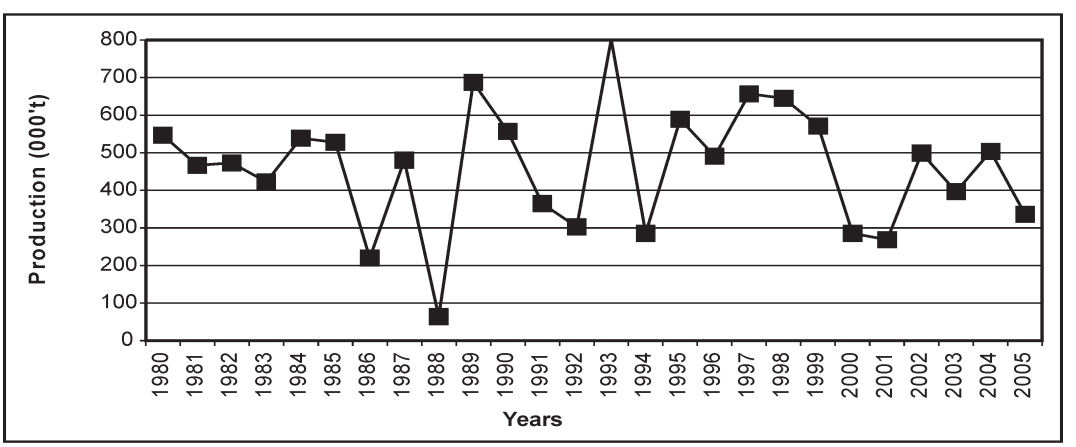
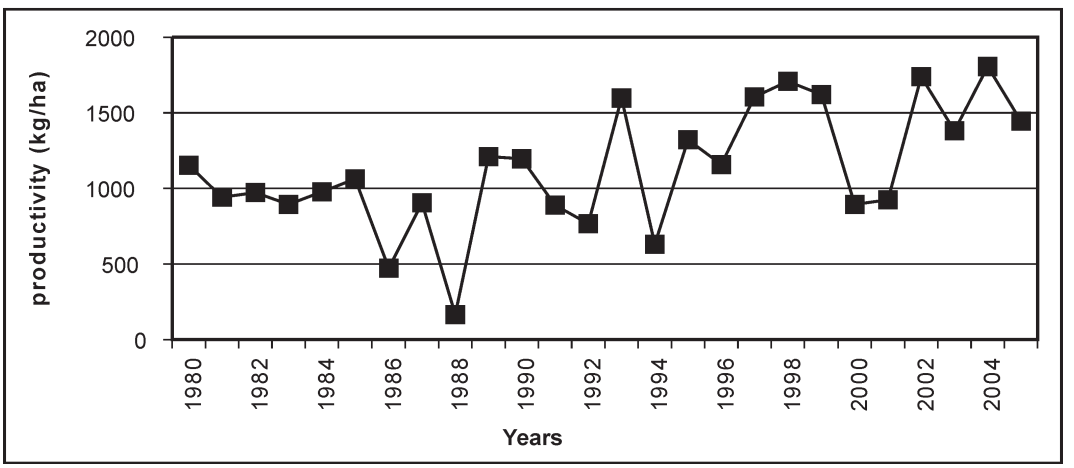


Fig. 15. Trends in Area, Production and Productivity of Pearlmillet in Gujarat (1980-2005)







State	District	Region
Gujarat	Amreli (Coastal Kathiawad) Bhavnagar and Junagadh (Central Kathiawad Peninsula)	Low runoff and Medium yield gap

Agro-geographic setting	Amreli	Bhavnagar	Junagadh
Climate	Hot dry semi arid, Hot moist semi arid	Hot dry semi arid, Hot moist semi arid	Hot dry semi arid, Hot moist semi arid
Soils	Orthids – 100%, Shallow and medium loamy to clayey black soils, deep black soils Deep loamy coastal alluvium - derived soils	Orthids – 75%; Vertic soils–25% Deep loamy gray brown and alluvium - derived soils, Shallow and medium loamy to clayey black soils, deep black soils,Deep loamy coastal alluvium - derived soils	Orthids – 50%; Vertic soils – 50% Shallow and medium loamy to clayey black soils, Deep black soils Deep loamy coastal alluvium - derived soils
Annual rainfall (mm)	607	602	702
Potential evapotranspiration (mm)	1877	1814	1684
Length of growing period (LGP) / moisture availability period (days)	90-150	90-150	90-150

Soil and water conservation

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

Crop management

Summer – GHB-558, GHB-526 (Sow within 15 days of onset of monsoon for harvesting maximum fodder yield)

Kharif GHB – 235, GHB –316, GHB –558, MH – 169, GHB-B2 (sow within 15 days of on set of monsoon for harvesting maximum fodder yield)

- **Seed rate:** 3.75 kg/ha
- **Planting pattern:** 60 X 15 cm
- **Nutrient management**
  - 80 kg N and 40 P_2O_5 / ha
  - Nirtogen in two splits (25% as basal + 75% at tillering) or Nitrogen in three splits i.e., 25% basal + 50% tillering + 25% flag leaf stage
  - Apply 80 kg N and 40 kg P_2O_5 / ha to the base crop of Pearlmillet in Pearlmillet + pigeonpea intercropping.

Suitable cropping systems

- GHB 558, GHB 577, Pusa – 23 should be grown in paired (40 cm apart with a spacing of 40 x 15 cm) in between two rows of greengram/cowpea/sesame
- Pearlmillet + greengram, pearlmillet + cowpea, pearl millet + sesame
- BJ-104 – should be grown in paired rows (40 cm apart with a spacing of 40 x 15 cm) in between two rows of pigeonpea (UPAS – 120) at a spacing of 120 x 45 cm
- Pearlmillet + pigeonpea (2:1/ 4:1)
- Pigeonpea (UPAS – 120 Hy-2) was used as mixed crop with pearlmillet (BJ-104) @ 38 kg N and 19 kg P_2O_5 /ha. Seed rates for pigeonpea and pearlmillet are 20 and 3.75 kg/ha respectively.
- Pearlmillet + kidneybean

Farm Implements / tools

- Two bowl seed cum fertilizer drill

Alternate Farming Systems

- **Fodder/ green biomass:** *Dichrostachys cineraria, Albizzia lebbeck, Leucaena leucocephala, Pongamia pinnata*

  On slopy fallow lands with shallow soils – *Dicanthium annulatum*; 16 rows of groundnut (GG-2) in alleys of perennial pigeonpea (ICPL-185); 16 rows of groundnut (GG-2) in alleys of subabul (Hawai gaint)
- **Fruit:** Custard apple, Mango, Pomegranate, Phalsa, Fig, Jamun, Tamarind
- **Medicinal/ Aromatic Plants:** *Plantago ovata, Cassia angustifolia, Liquorice.*
- **Vegetables:** Cowpea, Cluster bean, Brinjal, Okra, Long melon, Drumstick.
- **Animal Component:** Female / male cattle; female buffaloes, sheep, goat

Contingent planning

- **Delay in monsoon by**

15th July to 31st July	:	Grow erect groundnut (GG-2, GG-5, GG-7), Sesame (G-Til-1, G.Til-2), Castor (GAUCH-1), Hybrid pearlmillet (GHB-577, GHB-558, Pusa-23), Greengram (K-851, GM-4), Blackgram (T-9, TPU-4), Pigeonpea (ICPL-87, GT-100)
		Grow erect groundnut (GG-2, GG-5, GG-7), Sesame (G-Til-1, G.Til-2), Castor

(GAUCH-1), Hybrid pearlmillet (GHB-235, GHB-316, GHB-558), Greengram (K-851, GM-4), Blackgram (T-9, TPU-4), Pigeonpea (ICPL-87, GT-100)

1st August to 14th August : Grow pulses blackgram (T-9, TPU-4), forage maize / sorghum (Gundri, GFS-5), castor (GAUCH-1, GC-2) and sesame (Purva-1)

15th August to 31st August : Grow forage maize / sorghum (Gundri, GFS-5), sesame (Purva-1)

- **Drought spell after normal sowing**

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

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

- **Early withdrawal of monsoon**
  - Give life saving irrigation
  - Minimize moisture losses through complete removal of weeds
  - Perform interculturing to conserve soil moisture
  - Harvest the crop according to maturity of crop duration
  - Thin the plant population
- **Satisfactory late rains during September - October**
  - Relay cropping of castor, sunflower, sesame (Purva-1) and fodder sorghum
  - Second crops like rapeseed mustard and chickpea could be taken
  - Ratooning of sorghum

State	District	Region
Gujarat	Ahmedabad (North Gujarat Plains) Surendranagar Rajkot (North Kathiawad)	Low runoff and High yield gap

Agro-geographic setting	Ahmedabad	Surendra Nagar
Climate	Hot dry semi arid	Hot arid, Hot dry semi arid
Soils	Ustalf/Ustolls – 100% Deep loamy grey brown and alluvium - derived soils, Shallow and medium loamy to clayey black soils, Deep black soils	Ustalf/Ustolls – 60%; Vertic soils –40% Deep loamy desert soils Deep loamy saline and alkaline soils Deep loamy grey brown and alluvium - derived soils

Soil and water conservation

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

Annual rainfall (mm)	823	601
Potential evapotranspiration (mm)	1678	1970
Length of growing period (LGP) / moisture availability period (days)	90-120	60-120

- Inter-row water harvesting
- Dead furrows at 3.6 m interval

Crop management

- Varieties : *Kharif* – GHB – 558, GHB-577, Pusa – 23

  Summer – GHB – 558, GHB-526
- Seed rate: 3.75 kg/ha
- Planting pattern: 45 x 10-15 cm
- Nutrient management : 80 kg N and 40 kg P_2O_5 / ha. Apply ½ recommended dose of N and whole dose of P_2O_5 as basal and remaining ½ dose of N at tillering stage depending on soil moisture content

Suitable cropping systems

- Pearlmillet + cluster bean (2:1)
- Pearlmillet + cluster bean (Malosan or HG-75) (2:2)
- Greengram + pearlmillet (3:1)
- Pearlmillet + cowpea
- Pearlmillet + sesame
- Pearlmillet + cluster bean (2:1)
- Pearlmillet + cluster bean (Malosan or HG-75) (2:2)
- Greengram + pearlmillet (3:1)
- Pearlmillet+ kidney bean

Farm Implements / tools

- Seed cum ferti drill

Alternate Farming Systems

- **Fodder/ green biomass:** The farmers growing Ber (10x6 m) on light textured soils are advised to take inter crop of either greengram or sorghum (fodder), *A.lebbeck, A. indica, A. albida, Cassia siamea, D.sissoo, Alianthus excelsa*
- **Fruit:** Mango, Pomegranate, Guava, Ber, Fig, Jamun.
- **Medicinal/ Aromatic Plants:** *Plantago ovata, Cassia angustifolia, Liquorice*
- **Vegetables:** Drumstick, Cluster bean, Cowpea, Long melon, Okra.
- **Animal Component:** Female and male Cattle, Female Buffaloes and Goats

Contingent planning

- **Normal sowing (Early July)**

Crops	Varieties/ hybrids
Castor	GCH-4, GCH-5, GCH-6
Pearlmillet	GHB 558, GHB-235, GHB-316
Cowpea	Guj. Cowpea-4
Clusterbean	Guj. Clusterbean, Guj. Clusterbean-1
Greengram	Guj. mungbean, Guj. Mung-4
Sorghum	GSF-4
Mothbean	Guj.1
Karingado	Guj. Karingado-1

- **Delayed sowing (15th July to early August)**

Crops	Varieties
Castor	-GCH-4
Sorghum	-GSF-4
Cluster bean	Guj. Clusterbean-1
Pearlmillet	GHB-577, Pusa-23

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

Crop	Varieties
Castor	GCH-4

State	District	Region
Gujarat	Rajkot (North Kathiawmad)	Low run off and High yield gap

Agro-geographic setting	Rajkot
Climate	Hot arid, Hot dry semi arid
Soils	Vertic soils –80%; Vertisols – 20% Deep loamy saline and alkaline soils Deep loamy grey brown and alluvium - derived soils, Shallow and medium loamy to clayey black soils, Deep black soils
Annual rainfall (mm)	674
Potential evapotranspiration (mm)	2144
Length of growing period (LGP) / moisture availability period (days)	60-120

Soil and water conservation

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

Crop management

Varieties: GHB – 235, GHB –316, GHB –558, MH – 169, GHB-B2 (sow within 15 days of on set of monsoon for harvesting maximum fodder yield)

Summer-GHB-558, GHB-526

- **Seed rate**: 3.75 kg/ha
- **Planting pattern:** 60 X 15 cm
- **Nutrient management**
- 80 kg N and 40 kg P_2O_5 / ha
- Nitrogen in two splits (25% as basal + 75% at tillering) or Nitrogen in three splits i.e., 25% basal + 50% tillering + 25% flag leaf stage
- Apply 80 kg N and 40 kg P_2O_5 / ha to the base crop of pearlmillet in pearlmillet + pigeonpea intercropping.

Suitable cropping systems

- GHB 558, GHB 577 should be grown in paired (40 cm apart with a spacing of 40 x 15 cm) in between two rows of green gram/ cowpea/sesame
- Pearlmillet + greengram, pearlmillet + cowpea, pearl millet + sesame
- BJ-104 – should be grown in paired rows (40 cm apart with a spacing of 40 x 15 cm) in between two rows of pigeonpea (UPAS – 120) at a spacing of 120 x 45 cm
- Pearlmillet + Pigeonpea (2:1/ 4:1)
- Pigeonpea (UPAS – 120 Hy-2) was used as mixed crop with pearlmillet (BJ-104) @ 38 kg N and 19 kg P_2O_5 /ha. Seed rates for Pigeonpea and Pearlmillet are 20 and 3.75 kg/ha respectively.
- Pearlmillet + kidney bean

Farm Implements / tools

- Two bowl seed cum ferti drill

Alternate Farming Systems

- **Fodder/ green biomass:** *Dichrostachys cineraria, Albizzia lebbeck, Leucaena leucocephala, Pongamia pinnata*
- On slopy fallow lands with shallow soils – *Dicanthium annulatum*; 16 rows of groundnut (GG-2) in alleys of perennial pigeonpea (ICPL-185); 16 rows of groundnut (GG-2) in alleys of subabul (Hawai gaint)
- **Fruit:** Custard apple Mango, Pomegranate, Phalsa, Fig, Jamun, Tamarind
- **Medicinal/ Aromatic Plants:** *Plantago ovata, Cassia angustifolia, Liquorice.*
- **Vegetables:** Cowpea, Cluster bean, Brinjal, Okra, Long melon, Drumstick.
- **Animal Component:** Female / male cattle; female buffaloes, sheep, goat

Contingent planning

- **Delay in monsoon by**

15th July to 31st July : Grow erect groundnut (GG-2, GG-5, GG-7), Sesame (G-Til-1, G.Til-2), Castor (GAUCH-1), Hybrid pearlmillet (GHB 577, GHB 558, Pusa 23), Greengram (K-851, GM-4), Blackgram (T-9, TPU-4), Pigeonpea (ICPL-87, GT-100)

Grow erect groundnut (GG-2, GG-5, GG-7), sesame (G-Til-1, G.Til-2), castor (GAUCH-1), hybrid pearlmillet (GHB-235, GHB-316, GHB-558), greengram (K-851, GM-4), blackgram (T-9, TPU-4), pigeonpea (ICPL-87, GT-100)

1st August to 14th August : Grow pulses blackgram (T-9, TPU-4), forage maize / sorghum (Gundri, GFS-5), castor (GAUCH-1, GC-2) and sesame (Purva-1)

15th August to 31st August : Grow forage maize / sorghum (Gundri, GFS-5), sesame (Purva-1)

- **Drought spell after normal sowing**

1-2 weeks after sowing : Resowing of early duration varieties or alternate crops should be recommended as under, if sufficient rainfall is received. Hybrid pearlmillet (GHB-577, GHB-558), sorghum (GJ-39, J-41), sesame (G.Til-1, G-Til-2) and castor (GAUCH-1, GC-2), blackgram (T-9, TPU-4)

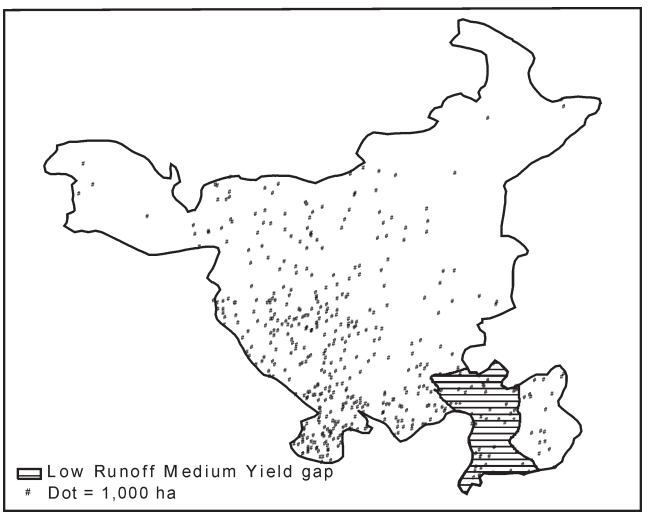
Resowing of early duration varieties or alternate crops should be recommended as under, if sufficient rainfall is received. Hybrid pearlmillet (GHB-235, GHB-316, GHB-558), sorghum (GJ-39, J-41), sesame (G.Til-1, G-Til-2) and castor (GAUCH-1, GC-2), blackgram (T-9, TPU-4)

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

- **Early withdrawl of monsoon**
  - Give life saving irrigation
  - Minimize moisture losses through complete removal of weeds
  - Perform interculturing to conserve soil moisture
  - Harvest the crop according to maturity of crop duration
  - Thin the plant population
- **Satisfactory late rains during September - October**
  - Relay cropping of castor, sunflower, sesame (Purva-1) and fodder sorghum
  - Second crops like mustard and chickpea could be taken
  - Ratooning of sorghum

HARYANA

In Haryana there is one district viz. Gurgaon under low runoff and medium yield gap region. The trends in area, production and productivity of pearlmillet in Haryana (1980 - 2005) are shown in Fig. 16.



State	District	Region
Haryana	Gurgaon (South East Haryana)	Low runoff and Medium yield gap

Agro-geographic setting	Gurgaon
Climate	Hot semi arid
Soils	Inceptisols – 100%, Deep loamy alluvium - derived soils
Annual rainfall (mm)	474
Potential evapotranspiration (mm)	1649
Length of growing period (LGP) / moisture availability period (days)	90-120

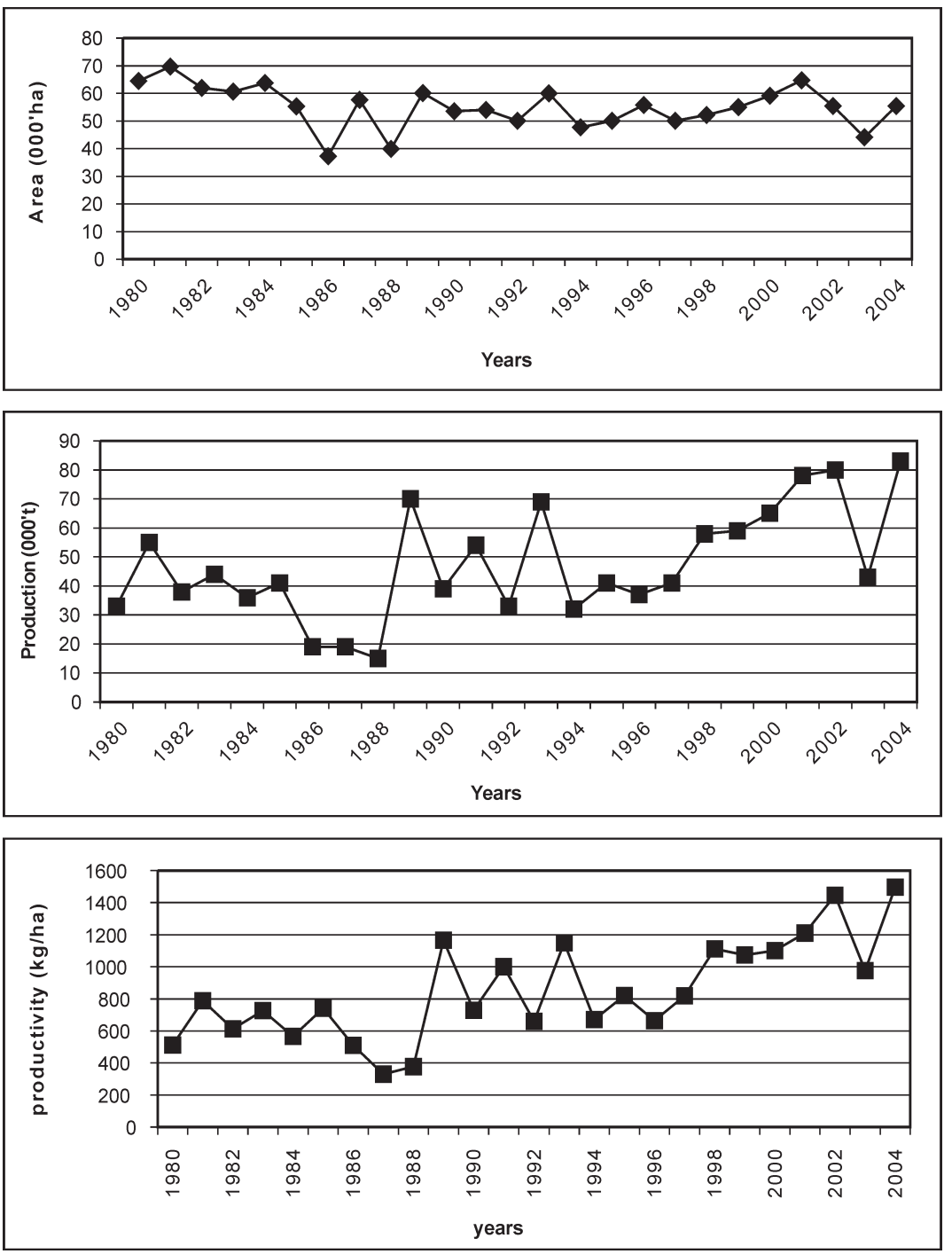
Soil and water conservation

- Increasing soil infiltration capacity and reducing soil crusting problem
- Inter-plot water harvesting of 1:1 cropped to uncropped land
- Dead furrows at 3.6 m interval
- Land shaping
- Pre monsoon/ summer tillage and ridge furrow configurations across the land slope to improve moisture storage.

Crop management

- **Varieties:** HHB-67, HHB-50, HHB-60, HHB-67-2

Fig. 16. Trends in Area, Production and Productivity of Pearlmillet in Haryana (1980-2005)



- **Seed rate:** 5 kg/ha
- **Planting pattern:** 45 x 15 cm
- **Nutrient management :** 40 kg N + 20 kg P_2O_5 /ha.

Suitable cropping systems

- Pearl millet + cluster bean
- Pearl millet + greengram
- Pearl millet + cowpea – rapeseed mustard/ Chickpea (fodder crop)
- Pearl millet + chickpea
- Pearlmillet – chickpea
- Pearlmillet + cowpea – rapeseed mustard/ Chickpea (fodder crop)
- Pearlmillet + greengram
- Pearlmillet + clusterbean

Farm Implements / tools

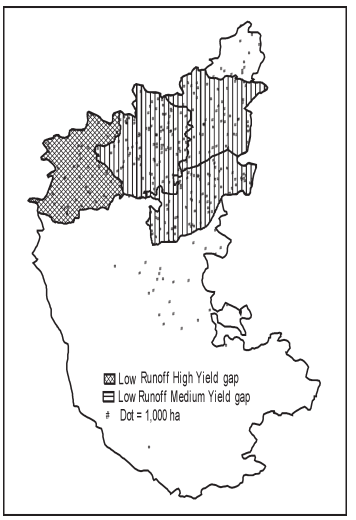
- Use of blade type wheel hand hoe to save time and energy for interculture operations
- Tractor – drawn ridger –seeder (3 point hich tools)
- Bullock-drawn Ridger seeds
- Bullock-drawn interculture blade harrow
- Hand wheel hoe

Alternate Farming Systems

- **Agri-Horti system** of ber intercropped with cowpea, greengram, clusterbean and anjan grass.
- **Fodder/ green biomass:** *A.lebbeck, P.cineraria, Melia azadirachta [saline soils], D.sissoo, A.indica.*
- **Fruit:** Guava, Amla, Karonda, Phalsa, Bael, Jamun
- **Medicinal & Aromatic Plants:** *Plantago ovata, Palma rosa, Vetiveria zyzanoides, Ocimum viride, Liquorice.*
- **Vegetables:** Tomato, Chillies Okra, Cowpea, Palak, Bottle gourd
- **Animal component:** Female Buffaloes, Sheep

KARNATAKA

In Karnataka there are three districts viz. Bijapur, Raichur and Gulbarga under low runoff and high yield gap region and one district viz. Belgaum under high runoff and high yield gap region. The trends in area, production and productivity of pearlmillet in Karnataka (1980 - 2005) are shown in Fig. 17.



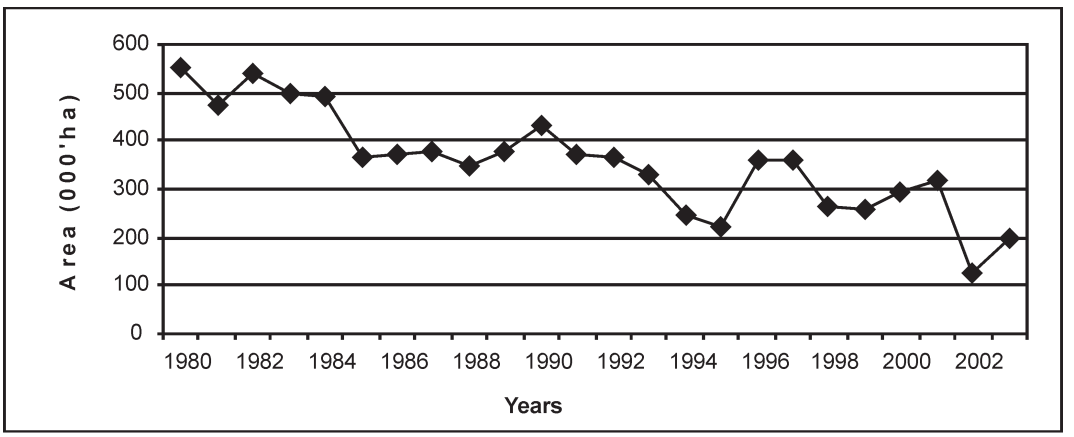
State	District	Region
Karnataka	Bijapur, Raichur and Gulbarga (North Karnataka Plateau)	Low runoff and High yield gap

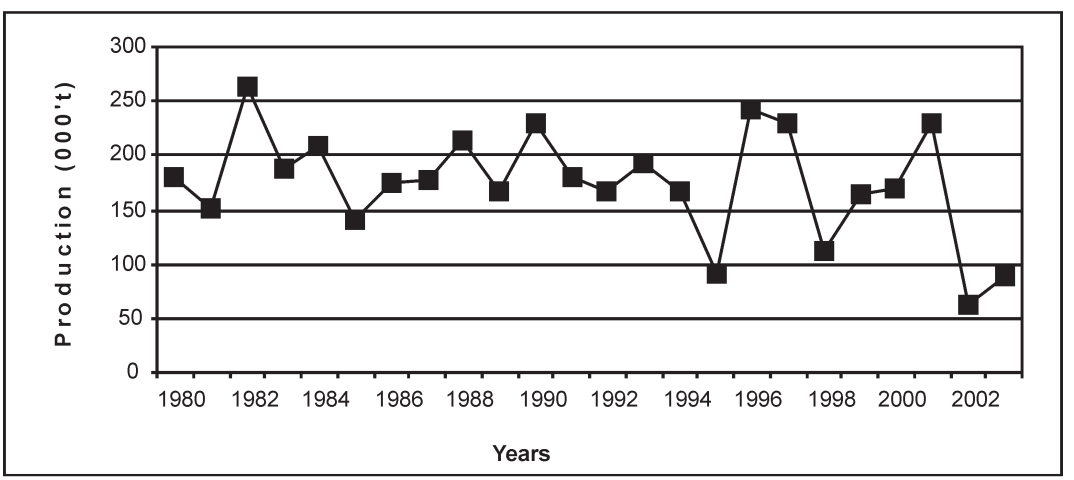
Agro-geographic setting	Bijapur	Raichur	Gulbarga
Climate	Hot arid	Hot arid	Hot semi arid
Soils	Vertisols – 50%; Vertic soils – 50%, Deep loamy and clayey mixed red and black soils	Vertisols –60%; Vertic soils – 40%, Deep loamy and clayey mixed red and black soils	Vertic soils –55%; Vertisols – 45% Shallow and Medium loamy, Medium and deep clayey black soils
Annual rainfall (mm)	573	719	753
Potential evapotranspiration (mm)	1649	1951	1915
Length of growing period (LGP) / moisture availability period (days)	60-120	60-120	120-150

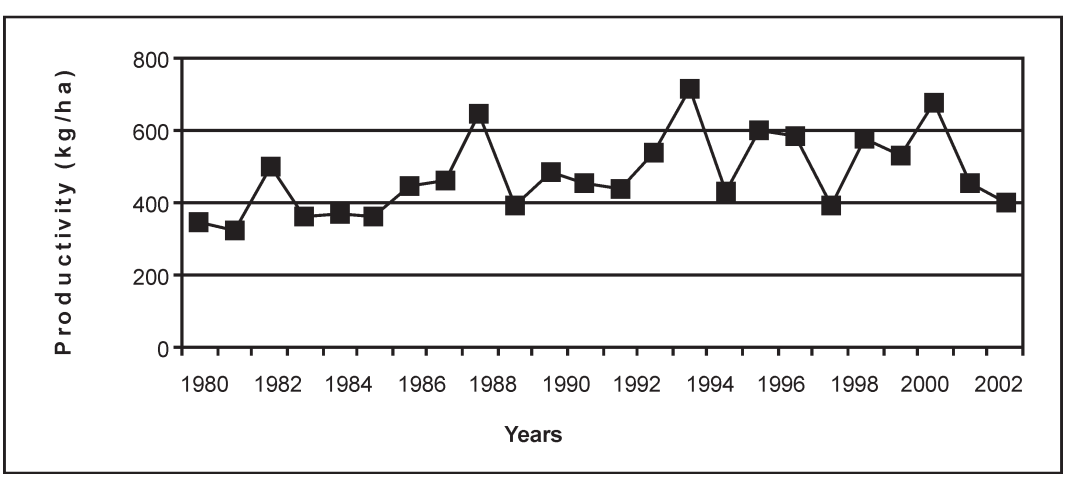
Soil and water conservation

- Rubbles at 0.3 m vertical interval on contour key lines
- Compartmental bunding, ridges and furrows, contour cultivation
- Planting Khus grass and subabul in paired rows at vertical interval of 0.3 m
- Bund stabilization through stylosanthes slope
- Bund planting with neem, sissoo and tamarind

Fig. 17. Trends in Area, Production and Productivity of Pearlmillet in Karnataka (1980-2005)







- A farm pond of 150 m^3 capacity for every one hectare catchment area to harvest excess runoff in medium to deep black soils
- *In-situ* moisture conservation practices like compartmental bunding, ridges and furrows contour cultivation and fall ploughing helped to conserve more moisture in deep black soils.

Crop management

- **Varieties:** ICTP-8203, ICMV-221, GHB-558, ICMH-356, MLBH-267
- **Seed rate:** 4 kg/ha
- **Planting pattern:** 60 x 15 cm
- **Nutrient management :**
  - Hybrids - 40 kg N + 40 kg P_2O_5 + 40 K_2O /ha.
  - Varieties – 50 kg N + 25 kg P_2O_5 /ha.

Some other important practices

- Shallow soils – sowing up to 15 th July.
- Medium black soils – sowing in June

Suitable cropping systems

- Hybrid Pearlmillet + sunflower / greengram (3:1)
- Hybrid Pearlmillet + pigeonpea (2:1)
- Pearlmillet + bunch groundnut (2:4)
- Hybrid Pearlmillet + pigeonpea (2:1)
- Pearlmillet + bunch groundnut (2:4)
- Hybrid Pearlmillet + castor (3:1)

Farm Implements / tools

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

Alternate Farming Systems

- **Fodder/ green biomass:** *D.sissoo, Glyricidia, A.lebbeck, H.binata, Cassia siamea, Azadirachta indica*
- **Fruit:** Mango, Pomegranate, Sapota, Ber, Jamun and Tamarind.
- **Medicinal/ Aromatic Plants:** *Cassia angustifolia, Catharanthus roseus, Palma rosa, Vetiveria zyzanoides,* Rose, Geranium
- **Vegetables:** Onion, Brinjal, chillies, Cowpea, Cucumber, Cluster bean, Drumstick.
- **Animal Component:** Female Cattle, Male Cattle, Female Buffaloes, Goat, Sheep and Poultry

Contingent planning

- **Normal onset of monsoon favorable for *kharif* crops:**
  - Take up sowing of the following crops in June in light soils. Groundnut (erect and spreading), pearlmillet, pigeonpea, *kharif* sorghum, setaria, hybrid sorghum and other crop mixtures like *kharif* sorghum + pigeonpea (2:1), groundnut + pigeonpea (4:2), setaria + pigeonpea (2:1) and 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 compartmental 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 dryland cotton before the middle of August. Grow *Herbaceum* cottons in place of *Hirsutams*. Early sowing of cotton is advantageous.
  - Sunflower, pigeonpea, and setaria should be sown in light soils and pigeonpea in medium to deep black soils.
  - In light textured soils in Hadagali, Koppal, Muddebihal, Raibag, and Athani castor may be sown. Plant castor on contour bunds also. In medium to deep black soils also take up castor sowing.
  - Relay cotton in groundnut in medium black soils.
- **Normal rains in September:**
  - Complete sowing of *rabi* sorghum by middle of September in medium black soils of northern taluks of Bijapur district. In the remaining taluks viz., Bagalkot, Hungund, and Mudhol, complete *rabi* sorghum sowing by first week of October. Early sowing of *rabi* sorghum in other districts is preferred. Maximum yields of *rabi* sorghum are obtained by sowing in September only.
  - Sow sunflower before 10th of September.

- Sow safflower as a sole crop before the end of September. Early sowing is more beneficial.
- Complete sowing of Bhagya/Laxmi cotton before 15th September.
- If normal rains are not received during September take up dry seeding of sunflower, *Rabi* sorghum, Chickpea with 1 ½ 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 row proportion.
  - Sow *rabi* sorghum and chickpea as mixed crops (random mixing).
  - Increase the area under safflower.
  - Sow chickpea and safflower in 4:2 or 3:1 row proportions for higher returns.
  - Top dress *rabi* sorghum with 10-15 kg N/ha if adequate moisture is available in the soil.
- **Early stoppage of rains towards the end of season:**
  - Thin out the population of *rabi* sorghum by blading every third row or alternate row within 40 days of sowing.
  - In mixed crops of *rabi* sorghum and safflower, uproot *rabi* sorghum component.
  - Close soil cracks by repeated interculturing.
  - Provide supplemental irrigation through farm ponds or other sources. By providing one or two supplemental irrigation(s) to *rabi* sorghum, safflower and chickpea, yields could be increased by 50 to 60 per cent.
  - Use surface mulches of mixed trash or farm waste wherever possible where farm waste is not available, use a blade to form a thin layer of soil mulch to avoid cracks.

State	District	Region
Karnataka	Belgaum (Western Karnataka Plateau)	High runoff and High yield gap

Agro-geographic setting	Belgaum
Climate	Hot dry sub humid
Soils	Vertic soils – 70%; Vertisols – 30%
	Shallow and medium loamy and clayey black soils, Deep clayey black soils
Annual rainfall (mm)	1551
Potential evapotranspiration (mm)	1482
Length of growing period (LGP) / moisture availability period (days)	150-180

Soil and water conservation

- Rubbles at 0.3 m vertical interval on contour key lines
- Compartmental bunding, ridges and furrows, contour cultivation

- Planting Khus grass and subabul in paired rows at vertical interval of 0.3 m
- Bund stabilization through stylosanthes slope
- 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
- *In-situ* moisture conservation practices like compartmental bunding, ridges and furrows contour cultivation and fall ploughing helped to conserve more moisture in deep black soils.

Crop management

- **Varieties:** BJ - 104
- **Seed rate:** 5 kg/ha
- **Planting pattern:** 60 cm rows
- **Nutrient management**
  - Hybrids - 40 kg N + 40 kg P_2O_5 + 40 K_2O/ha.
  - Varieties – 50 kg N + 25 kg P_2O_5 /ha.

Some other important practices

- Shallow soils – sowing up to 15th July
- Medium black soils – sowing in June

Suitable cropping systems

- Hybrid Pearlmillet + pigeonpea (2:1)
- Pearlmillet + bunch groundnut (2:4)
- Hybrid pearlmillet + castor (3:1)

Farm Implements / tools

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

Alternate Farming Systems

- Agave (*Agave sisolana* with 10, 000 plants /ha) intercropped with subabul . Cutting of agave leaves once in a year for fibre extraction with retaining top ten leaves
- **Silviculture**
  - Shallow black soils: *Casuarina, Dalbergia sissoo, Hardwikia binata, Acacia nitotica, Prosopis cineraria*
  - Marginal land: *Dalbergia sissoo*, neem, *Acacia nitotica*, Subabul
  - Aley croppying: Subabul / casuarina + *Kharif* crops
  - Agro horti system: Ber (umran) + curry leaf
  - Vegetable – curry leaf

  - Ber (umran) – safflower + chickpea
  - Ber / custard apple/ pomegrante / amla + *kharif* (spreading) crops
- **Horticulture**: Mango plants in leveled portion of zing conservation terrace
- **Fodder/ green biomass:** *D.sissoo, Glyricidia, A.lebbeck, H.binata, Cassia siamea, Azadirachta indica*
- **Fruit:** Mango, Pomegranate, Sapota, Ber, Jamun and Tamarind.
- **Medicinal/ Aromatic Plants:** *Cassia angustifolia, Catharanthus roseus, Palma rosa, Vetiveria zyzanoides,* Rose, Geranium
- **Vegetables:** Onion, Brinjal, chillies, Cowpea, Cucumber, Cluster bean, Drumstick.
- **Animal Component:** Female and male Cattle, Female Buffaloes, Goat, Sheep, Poultry

Contingent planning

- **Normal onset of monsoon favorable for *kharif* crops:**
  - Take up sowing of the following crops in June in light soils. Groundnut (erect and spreading), pearlmillet, pigeonpea, *kharif* sorghum, setaria, hybrid sorghum and other crop mixtures like *kharif* sorghum + pigeonpea (2:1), groundnut + pigeonpea (4:2), setaria + pigeonpea (2:1) and 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 compartmental 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 harrowing 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 dryland cotton before the middle of August. Grow *Herbaceum* cottons in place of *Hirsutams.* Early sowing of cotton is advantageous.
  - Sunflower, pigeonpea, and setaria should be sown in light soils and pigeonpea in medium to deep black

soils.

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

- **Normal rains in September:**

  - Complete sowing of *rabi* sorghum by middle of September in medium black soils of northern taluks of Bijapur district. In the remaining taluks viz., Bagalkot, Hungund, and Mudhol, complete *rabi* sorghum sowing by first week of October. Early sowing of *rabi* sorghum in other districts is preferred. Maximum yields of *rabi* sorghum are obtained by sowing in September only.
  - Sow sunflower before 10th of September.
  - Sow safflower as a sole crop before the end of September. Early sowing is more beneficial.
  - Complete sowing of Bhagya/Laxmi cotton before 15th September.
  - If normal rains are not received during September take up dry seeding of sunflower, *Rabi* sorghum, Chickpea with 1 ½ 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 row proportion.
  - Sow *rabi* sorghum and chickpea as mixed crops (random mixing).
  - Increase the area under safflower.
  - Sow chickpea and safflower in 4:2 or 3:1 row proportions for higher returns.
  - Top dress *rabi* sorghum with 10-15 kg N/ha if adequate moisture is available in the soil.

- **Early stoppage of rains towards the end of season:**

  - Thin out the population of *rabi* sorghum by blading every third row or alternate row within 40 days of sowing.
  - In mixed crops of *rabi* sorghum and safflower, uproot *rabi* sorghum component.
  - Close soil cracks by repeated interculturing.
  - Provide supplemental irrigation through farm ponds or other sources. By providing one or two supplemental irrigation(s) to *rabi* sorghum, safflower and chickpea, yields could be increased by 50 to 60 per cent.
  - Use surface mulches of mixed trash or farm waste wherever possible where farm waste is not available, use a blade to form a thin layer of soil mulch to avoid cracks.

MAHARASHTRA

In Maharashtra there are two districts viz. Dhule and Jalna under low runoff and medium yield gap region, seven districts viz. Ahamednagar, Beed, Nasik, Pune, Aurangabad, Sangli and Jalgaon under low runoff and high yield gap region and one district viz. Satara under high runoff and high yield gap region.

State	District	Region
Maharshtra	Dhule and Jalna (Western Maharshtra Plateau)	Low runoff and Medium yield gap

Agro-geographic setting	Dhule	Jalna
Climate	Hot semi arid	Hot semi arid
Soils	Vertic soils –65%; Vertisols – 35% Shallow and Medium loamy Medium and deep clayey black soils	Vertic soils – 75%; Vertisols –25% Shallow and Medium loamy, Medium and deep clayey black soils
Annual rainfall (mm)	738	1472
Potential evapotranspiration (mm)	1713	1559
Length of growing period (LGP) / moisture availability period (days)	120-150	120-150

Soil and water conservation

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

Crop management

- **Varieties:** RHRBH-8924, RHRBH-8604, AHB-251, PAC-903, AIMP-92901, MLBH-504, MLBH-267, Nandi-35, GK-1004, ICTP – 8203, Sangam Shradha, ICMV – 87901,

  Hybrids: Shradha, RHRBH -8603
- **Seed rate:** Hybrids - 3.75 – 4 kg/ha

  Varieties: 2.5 kg/ha
- **Planting pattern:** 45 X 15 cm
- **Nutrient management :** 50 kg N + 25 kg P_2O_5 /ha.

Some other important practices

- Sowing up to first fortnight of July
- Seed treatment with 10% brine solution for ergot affected seed
- Seed treatment with Thiram or Captan 3 g / kg of seed
- Protective irrigation, if available, at tillering and at flowering

- Sowing up to first fortnight of July
- Seed treatment with 20% brine solution for ergot affected seed
- Seed treatment with Thiram or Captan 3 g / kg of seed
- Protective irrigation, if available, at tillering and at flowering

Suitable cropping systems

- Pearlmillet + kidney bean/ horse gram (2:1) for shallow soils
- Pearlmillet + pigeonpea (2:1) – for medium deep soils
- Pearlmillet + kidney bean/ horse gram (2:1) for shallow soils
- Pearlmillet + pigeonpea (2:1) – for medium deep soils

Farm Implements / tools

Tool/Implement	Cost	Operation carried
1) Tractor multicrop planter	Rs.22800/-	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.
2) Bullock drawn Jyoti Planter.	Rs.7500/-	The field trials were conducted and the machine is recommended for sowing the crops of dryland region.
3) Weeders developed by Maharashtra Agro Industries Development Corporation Ltd. (MAIDC)	Rs.410/-	These weeders were tested on farmer's field and identified for weeding and interculturing in row crops.
4) Tractor drawn a) Single bottom reversible plough. b) Double bottom reversible plough.	 Rs.18500/- Rs.23600/-	Tested on farmers' field for ploughing and identified for ploughing operations in dryland region as the field operation was effective and economical.
5) Bund former	Rs.1050/-	Bund formers were tested and found suitable for compartmental bunding.
6) Baliram plough	Rs.2500/-	Identified for moisture conservation practices like ridges and furrows and compartmental bunding.
7) Kopergaon bullock drawn two-bowl seed drill.	Rs.9000/-	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.

Alternate Farming Systems

- **Silvipasture:** *Leucaena* + Marvel –8
- **Alley cropping**: Ber (20 m alleys) + pearlmillet + pigeonpea for shallow soils
- **Fodder**: Maize (African Tall) Oats (Kent), Stylo hamata

- **Fodder/ green biomass:** *Dalbergia sissoo, Albizzia lebbeck, Anogeissus latfolia, Sesbania, Stylo Marvel – 8 grass*
- **Fruit:** Ber, Custard apple, Pomegranate, amla+ *kharif* spreading crops
- **Medicinal/ Aromatic Plants:** *Catharanthus roseus, Palma rosa, Vetiveria zyzanoides,* Rose, Geranium
- **Vegetables:** Onion, Tomato, Okra, Cowpea, Cluster bean, Drumstick
- **Animal Component:**
- **Cow breeds:** Gir, Jersey
- **Poultry:** White Leghorn
- Rams
- Male/ female cattle, female buffaloes, sheep, goat

Alternate land use system

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

Contingent planning

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

2nd Fortnight of June	All *kharif* crops
1st 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)
2nd Fortnight of July	Sunflower, Pigeonpea, Horsegram, Setaria, Castor, Pearlmillet (ergot resistant), Intercropping of Sunflower + Pigeonpea (2:1)
1st Fortnight of August	Sunflower, Pigeonpea, Castor, Horsegram, Sunflower + Pigeonpea (2:1)
2nd Fortnight of August	Sunflower, Pigeonpea, Castor, Sunflower + Pigeonpea (2:1)
1st Fortnight of September	Sorghum for fodder
2nd Fortnight of September	*Rabi* Sorghum, Safflower, Sunflower
1st Fortnight of October	Rabi Sorghum, Safflower, Chickpea, Sunflower
2nd Fortnight of October	Chickpea, Sunflower, *Rabi* Sorghum.
1st Fortnight of November	Chickpea, Sunflower.

State	District	Region
Maharashtra	Ahmednagar, Beed and Nasik (Western Maharashtra Plateau) Pune (North Sahayadris) Aurangabad (Central Maharashtra Plateau) Sangli (South Western Maharashtra) Jalgaon (Eastern Maharashtra)	Low runoff and High yield gap

Agro-geographic setting	Ahmednagar	Beed	Nasik	Pune
Climate	Hot dry semi arid	Hot dry semi arid	Hot semi arid	Hot semi arid Hot dry sub humid Hot humid
Soils	Vertic soils – 60%; vertisols – 40% Shallow and medium loamy black soils, Deep clayey black soils	Vertic soils –100% Shallow and medium loamy black soils Deep clayey black soil	Vertic soils –85%; Vertisols – 15% Shallow and Medium loamy Medium and deep clayey black soils	Vertic soils- 65%; Vertisols – 35% Shallow and Medium loamy Medium and deep clayey black soils Shallow and medium loamy and clayey black soils, Deep clayey black soils Medium to deep loamy to clayey mixed red and black soils
Annual rainfall (mm)	676	685	591	715
Potential evapotranspiration (mm)	1605	1606	1659	1476
Length of growing period (LGP) / moisture availability period (days)	90-120	90-120	120-150	90-240

Agro-geographic setting	Aurangabad	Sangli	Jalgaon
Climate	Hot semi arid	Hot semi arid Hot dry sub humid	Hot semi arid Hot moist semi arid
Soils	Vertic soils – 80%; Vertisols – 20% Shallow and Medium loamy Medium and deep clayey black soils	Vertic soils – 75%; Vertisols – 25% Shallow and Medium loamy Medium and deep clayey black soils Shallow and medium loamy and clayey black soils, Deep clayey black soils	Vertic soils–65% Vertisols – 35% Shallow and Medium loamy Medium and deep clayey black soils Shallow loamy to clayey black soils
Annual rainfall (mm)	786	571	841
Potential evapotranspiration (mm)	1774	1620	1912
Length of growing period (LGP) / moisture availability period (days)	90-240	90-180	120-150

Soil and water conservation

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

Crop management

- **Varieties:** ICTP-8203, GK-1004, PAC-903, Nandi-35, Saburi, GHB-558, Sharadha
  Hybrids: Shradha, RHRBH -8603
- **Seed rate:** Hybrids - 3.75 – 4kg/ha
  Varieties: 3 kg /ha
- **Planting pattern:** 45 X 15 cm
- **Nutrient management :** 50 kg N + 25 kg P_2O_5 /ha.

Suitable cropping systems

- Pearlmillet + kidney bean/ horse gram (2:1) for shallow soils
- Pearlmillet + pigeonpea (2:1) for medium deep soils
- Pearlmillet + kidney bean/ horse gram (2:1) for shallow soils
- Pearlmillet + pigeonpea (2:1) for medium deep soils

Farm Implements / tools

Tool/Implement	Cost	Operation carried
1) Tractor multi crop planter	Rs.22800/-	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.
2) Bullock drawn Jyoti Planter.	Rs.7500/-	The field trials were conducted and the machine is recommended for sowing the crops of dryland region.
3) Weeders developed by Maharashtra Agro Industries Development Corporation Ltd. (MAIDC)	Rs.410/-	These weeders were tested on farmer's field and identified for weeding and interculturing in row crops.
4) Tractor drawn a) Single bottom reversible plough. b) Double bottom reversible plough.	 Rs.18500/- Rs.23600/-	Tested on farmers' field for ploughing and identified for ploughing operations in dryland region as the field operation was effective and economical.
5) Bund former	Rs.1050/-	Bund formers were tested and found suitable for compartmental bunding.
6) Baliram plough	Rs.2500/-	Identified for moisture conservation practices like ridges and furrows and compartmental bunding.
7) Kopergaon bullock drawn two-bowl seed drill.	Rs.9000/-	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.

Alternate Farming Systems

- **Silvipasture:** *Leucaena* + Marvel – 8
- **Alley cropping**: Ber (20 m alleys) + Pearlmillet + pigeonpea for shallow soils
- **Fodder:** Maize (African Tall), Oats (Kent), *Stylosanthes*
- **Fodder/ green biomass:** *Dalbergia sissoo, Albizzia lebbeck, Anogeissus latfolia, Sesbania, Stylo Marvel – 8 grass*
- **Fruit:** Ber, Custard apple, Pomegranate, amla+ *kharif* spreading crops
- **Medicinal/ Aromatic Plants:** *Catharanthus roseus, Palma rosa, Vetiveria zyzanoides, Rose, Geranium*
- **Vegetables:** Onion, Tomato, Okra, Cowpea, Cluster bean, Drumstick
- **Animal component:**
  - Cow breeds: Gir, Jersey
  - Poultry: White Leghorn
  - Rams
  - Male/ female cattle, female buffaloes, sheep, goat

Alternate land use system

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

Contingent Planning

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

2nd Fortnight of June	All *kharif* crops
1st 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)
2nd Fortnight of July	Sunflower, Pigeonpea, Horsegram, Setaria, Castor, Pearlmillet (ergot resistant), Intercropping of Sunflower + Pigeonpea (2:1)
1st Fortnight of August	Sunflower, Pigeonpea, Castor, Horsegram, Sunflower + Pigeonpea (2:1)
2nd Fortnight of August	Sunflower, Pigeonpea, Castor, Sunflower + Pigeonpea (2:1)
1st Fortnight of September	Sorghum for fodder

2nd Fortnight of September	*Rabi* Sorghum, Safflower, Sunflower
1st Fortnight of October	Rabi Sorghum, Safflower, Chickpea, Sunflower
2nd Fortnight of October	Chickpea, Sunflower, *Rabi* Sorghum.
1st Fortnight of November	Chickpea, Sunflower.

State	District	Region
Maharashtra	Satara (North Sahayadris)	High runoff and High yield gap

Agro-geographic setting	Satara
Climate	Hot semi arid Hot dry sub humid
Soils	Shallow and Medium loamy, Medium and deep clayey black soils Shallow and medium loamy and clayey black soils, Deep clayey black soils
Annual rainfall (mm)	1119
Potential evapotranspiration (mm)	1618
Length of growing period (LGP) / moisture availability period (days)	90-180

Soil and water conservation

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

Crop management

- **Varieties:** ICTP-8203, Saburi GHB-558, Sharadha, Raj-171, ICMV-155

  Hybrids: Shradha, RHRBH - 8603
- **Seed rate:** Hybrids - 3.75 – 4kg/ha

  Varieties: 3 kg /ha
- **Planting pattern:** 45 X 15 cm
- **Nutrient management :** 50 kg N + 25 kg P_2O_5 /ha.

Suitable cropping systems

- Pearlmillet + kidney bean/ horse gram (2:1) for shallow soils
- Pearlmillet + pigeonpea (2:1) – for medium deep soils
- Pearlmillet + kidney bean/ horse gram (2:1) for shallow soils
- Pearlmillet + pigeonpea (2:1) – for medium deep soils

Farm Implements / tools

Tool/Implement	Cost	Operation carried
1) Tractor multicrop planter	Rs.22800/-	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.
2) Bullock drawn Jyoti Planter.	Rs.7500/-	The field trials were conducted and the machine is recommended for sowing the crops of dryland region.
3) Weeders developed by Maharashtra Agro Industries Development Corporation Ltd. (MAIDC)	Rs.410/-	These weeders were tested on farmer's field and identified for weeding and interculturing in row crops.
4) Tractor drawn a) Single bottom reversible plough. b) Double bottom reversible plough.	 Rs.18500/- Rs.23600/-	Tested on farmers' field for ploughing and identified for ploughing operations in dryland region as the field operation was effective and economical.
5) Bund former	Rs.1050/-	Bund formers were tested and found suitable for compartmental bunding.
6) Baliram plough	Rs.2500/-	Identified for moisture conservation practices like ridges and furrows and compartmental bunding.
7) Kopergaon bullock drawn two bowl seed drill.	Rs.9000/-	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.

Alternate Farming Systems

- **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***: Dalbergia sissoo, Albizzia lebbeck, Anogeissus latfolia, Sesbania,* Stylo Marvel – 8 grass
- **Fruit:** Ber, Custard apple, Pomegranate, amla +*kharif* spreading crops
- **Medicinal/ Aromatic Plants:** *Catharanthus roseus, Palma rosa, Vetiveria zyzanoides, Rose, Geranium*
- **Vegetables:** Onion, Tomato, Okra, Cowpea, Cluster bean, Drumstick
- **Animal Component:**
    - **Cow breeds:** Gir, Jersey
    - **Poultry:** White Leghorn
    - Rams
    - Male/ female cattle, female buffaloes, sheep, goat

Alternate land use system

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

Contingent Planning

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

2nd Fortnight of June	All *kharif* crops
1st 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)
2nd Fortnight of July	Sunflower, Pigeonpea, Horsegram, Setaria, Castor, Pearlmillet (ergot resistant), Intercropping of Sunflower + Pigeonpea (2:1)
1st Fortnight of August	Sunflower, Pigeonpea, Castor, Horsegram, Sunflower + Pigeonpea (2:1)
2nd Fortnight of August	Sunflower, Pigeonpea, Castor, Sunflower + Pigeonpea (2:1)
1st Fortnight of September	Sorghum for fodder
2nd Fortnight of September	*Rabi* Sorghum, Safflower, Sunflower
1st Fortnight of October	Rabi Sorghum, Safflower, Chickpea, Sunflower
2nd Fortnight of October	Chickpea, Sunflower, *Rabi* Sorghum.
1st Fortnight of November	Chickpea, Sunflower.

RAJASTHAN

In Rajasthan there are four districts viz. Alwar, Dholpur, Bharatpur and Sawaimadhapur under low runoff and medium yield gap region, one district viz. Jaipur under low runoff and high yield gap region. The trends in area, production and productivity of pearlmillet in Rajasthan (1980 - 2005) are shown in Fig. 18.

State	District	Region
Rajasthan	Alwar, Dholpur and Bharatpur (North Rajasthan Uplands) Sawaimadhapur (Eastern Rajasthan Uplands)	Low runoff and Medium yield gap

Agro-geographic setting	Alwar	Dholpur	Bharatpur	Sawaimadhapur
Climate	Hot semi arid	Hot semi arid	Hot semi arid	Hot semi arid
Soils	Inceptisols- 100%, Deep loamy alluvium - derived soils	Vertic soils – 100%, Deep loamy alluvium - derived soils	Inceptisols –85%; Vertic soils – 15%, Deep loamy alluvium - derived soils	Vertic soils –85%; Inceptisols – 15%, Deep loamy alluvium - derived soils
Annual rainfall (mm)	725	722	722	753
Potential evapotranspiration (mm)	1595	150	1500	1569
Length of growing period (LGP) / moisture availability period (days)	90-120	90-120	180	90-120

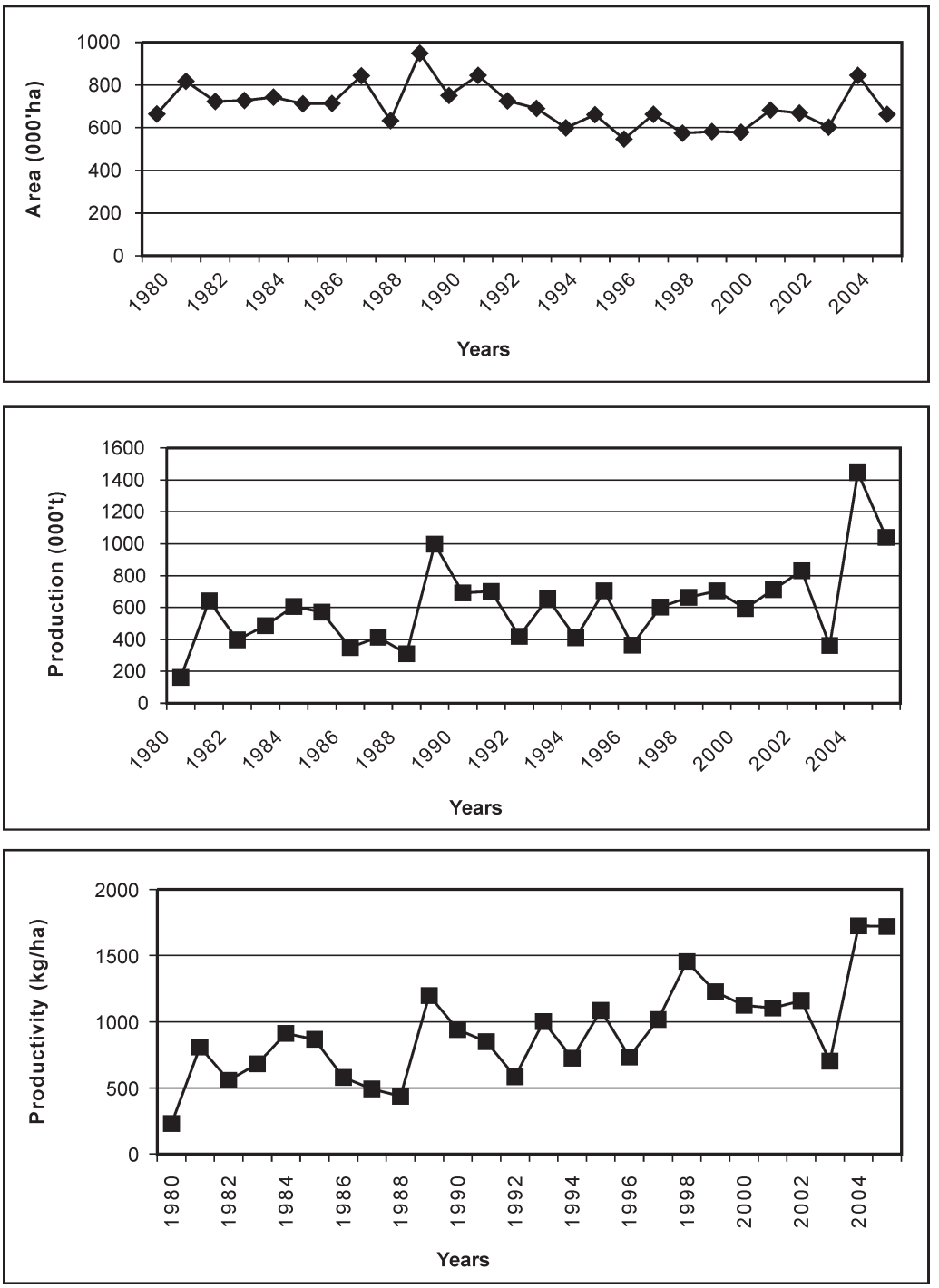
Soil and water conservation

- Compartmental bunding after seedling emergence
- Contour farming
- Graded border strips
- Sowing across the slope and ridging later
- To mitigate early season drought, one extra inter cultivation along with straw mulch @ 5t/ha is effective.
- One protective irrigation is only solution to control late season drought effect during summer.
- Deep tillage during summer and making compartmental bunding after seedlings emergence.
- Criss-cross ploughing by country plough after each effective rainfall.
- 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 the adverse effect of late season drought.

Crop management

- **Varieties:** HHB 67,RHB 90, RHB 121, JIC, Proagro, Raj 171, Raj Bajra chari, MBH – 110, MBH – 163, WCC – 75
- **Seed rate:** 3.5-4kg/ha
- **Planting pattern:** 45 X 15 cm

Fig. 18. Trends in Area, Production and Productivity of Pearlmillet in Rajasthan (1980-2005)



- **Nutrient management**
- 60 kg N and 40 kg P_2O_5/ ha. P as basal and N in two equal splits 25% at sowing and 75% at tiller initiation
- 60 kg N and 40 kg P_2O_5/ ha. P as basal and N in two equal splits at sowing and tiller initiation
- 30 kg N through FYM and 30 kg N through inorganic fertilizers

Some other important practices

- Sowing in lines
- Extra inter cultivation along with mustard straw mulch @ 5 tons/ha increase pearlmillet yield in early season drought situation.
- Removal of every third row increase the pearlmillet yield in late season drought
- Transplanting of pearlmillet along with one protective irrigation is much advantageous under late seeding condition.
- Transplanting along with one protective irrigation in late seeding condition
- Mulching with wheat straw @5 t/ha
- Pearlmillet + cowpea (2:1) is grown for fodder and harvested after 45 to 50 days up to end of Hugust
- Deep tillage along with compartmental bunding + 60 kg N/HA

Suitable cropping systems

- Pearl millet + cowpea
- Pearl millet + greengram
- Pearlmillet – chickpea
- Pearlmillet + pigeonpea (2:1)
- Pearlmillet + blackgram (2:1)
- Pearlmillet + clusterbean (2:1)

Expected yield increase: 15-20%

Farm Implements / tools

- Dryland weeder is quite effective and economic in controlling the weeds in both seasons.

Alternate Farming Systems

- **Marginal lands :**
- **Silviculture:** *Acacia tortilis*
- **LCC III :** Alley cropping (Jatropha spp + Greengram)
- **LCC IV :** Silvipastoral system: *Prosopis cineraria* + *Cenchrus sp*
- **Horti – Pastoral system:** Ber + *Cenchrus setigerus*
- **Fodder/green biomass**: A.*indica, Leucaena, A. lebbeck, H. binata, Pongamia, C. siamea, Bauhinia*
- **Fruit:** Mango, gauva, Amla, Phalsa, Jamun, Caronda
- **Medicinal & Aromatic Plants:** *Papaver somniferum, Palma rosa, Cymbopogan flexuosus, Vetiveria zyzanoides*

- **Vegetables:** Tomato, Chillies, Brinjal, Okra, Bottle gourd, Amaranthus, Cowpea.
- **Animal Component:** Female Cattle, Female Buffaloes, Goat and Poultry

Contingent planning

- ***Kharif***
- **Under normal rainfall:** Pearl millet (HHB 67, RHB 90, RHB 121, JK, Proagro, Raj 171, Raj Bajra Chari)

  Under normal rainfall: Pearlmillet (Proagro 9402), pigeonpea (UPAS 120), greengram (K 851), Clusterbean (RGC 197)
- As the monsoon progresses
- **Rainfall upto end of July:**
  - Pearl millet (HHB 67, RHB 90, RHB 121, JK, Proagro, Raj 171, Raj Bajra Chari) intercropped with cluster bean and cowpea
- **Rainfall upto third week of August**
  - Cereals and pluses: Cluster bean (RGC 197) and transplanting of peral millet (HHB 67- 2)
- **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) and
  - Taramira (TMH-1) and safflower in the order.

State	District	Region
Rajasthan	Jaipur (Central Rajasthan Uplands)	Low runoff and High yield gap

Agro-geographic setting	Jaipur
Climate	Hot semi arid
Soils	Inceptisols – 100%, Deep loamy alluvium - derived soils
Annual rainfall (mm)	647
Potential evapotranspiration (mm)	1745
Length of growing period (LGP) / moisture availability period (days)	90-120

Soil and water conservation

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

Crop management

- **Varieties:** RHB-90, RHB-121, JK, Proagro, Raj-171, Raj Bajra chari

  Hybrids: GHB – 27, GHB-30, GHB-32, GHB-235, GHB- 181, GHB-15
- **Seed rate :** 3.75-4 kg/ha
- **Planting pattern:** 60 x 15 cm
- **Nutrient management :** 80 kg N + 40 kg P_2O_5 /ha.

Suitable cropping systems

- Pearl millet + cluster bean (2:1)
- Pearl millet + greengram)
- Pearlmillet + pigeonpea (2:1)

Farm Implements / tools

- Multipurpose Tool bar
- Dry land weeder

Alternate Farming Systems

Marginal lands :

- **Silviculture:** *Acacia tortilis*
- **LCC III :** Alley cropping (Jatropha spp + Greengram)
- **LCC IV :** Silvipastoral system (*Prosopis cineraria* + *cenchrus*)
- **Horti – Pastoral system:** Ber + *cenchrus setigerus*
- **Fodder/ green biomass:** *Alianthus excelsa, A.lebbeck, D.sissoo, A.indica, P.cineraria, Dichrostachys*
- **Fruit:** Ber, Date palm, Jamun,Fig, Phalsa, Karonda
- **Medicinal/ Aromatic Plants:** *Plantago ovata, Cassia angustifolia, Safed musli, Papaver somniferum*
- **Vegetables:** Clusterbean, Cowpea, Amaranth, round melon, Long melon

- **Animal Component:** Female and male Cattle, Female Buffaloes, Sheep, Goats

Contingent planning

- **Good and normal rainfall**

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

- **Normal onset followed by long gaps in rainfall**

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

- **Delayed onset of monsoon**:

  Grow early maturing pulses (greengram, blackgram), oilseeds (sesame) and fodder crops (sorghum + cowpea). Intercropping of maize + blackgram / pigeon pea, 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.

TAMIL NADU

In Tamil Nadu there are two districts viz. Tiruchirapalli and South Arcot under low runoff and high yield gap region. The trends in area, production and productivity of pearlmillet in Tamil Nadu (1980 - 2005) are shown in Fig. 19.

State	District	Region
Tamil Nadu	Tiruchirapalli (Uplands, Central Tamil Nadu) South Arcot (Central East Tamil Nadu)	Low runoff and Medium yield gap

Agro-geographic setting	Tiruchirapalli	South Arcot
Climate	Hot moist semi arid	Hot moist arid Semi hot moist semi arid
Soils	Orthids – 25%; Sandy Alfisol- 75%, Deep red loamy soils	Orthids –85%; Sandy Alfisol – 15% Deep red loamy soils Deep clayey and cracking coast and deltaic alluvium - derived soils
Annual rainfall (mm)	869	923
Potential evapotranspiration (mm)	2091	1826
Length of growing period (LGP) / moisture availability period (days)	120-150	120-150

Soil and water conservation

- Soil water balance studies
- Runoff-erosion measurements
- More emphasis on *in situ* water conservation
- Increasing soil infiltration capacity and reducing soil crusting problem
- Inter-plot water harvesting of 1:1 cropped to uncropped land
- Dead furrows at 3.6 m interval
- Absorption/drainage type terraces
- On sloppy land contour cultivation along vegetative hedge of Vetiver or *Leucaena* at 0.5 m V.I. in sorghum and cotton crops.

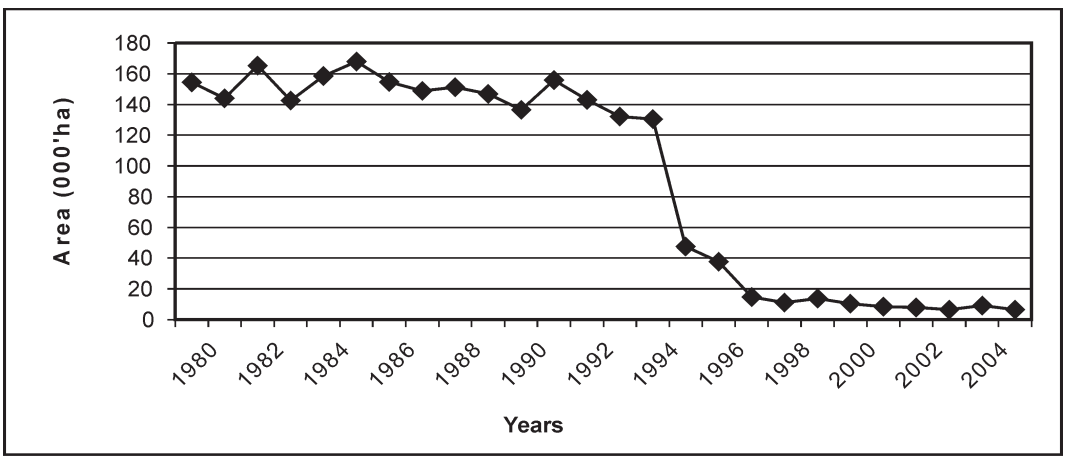
Crop management

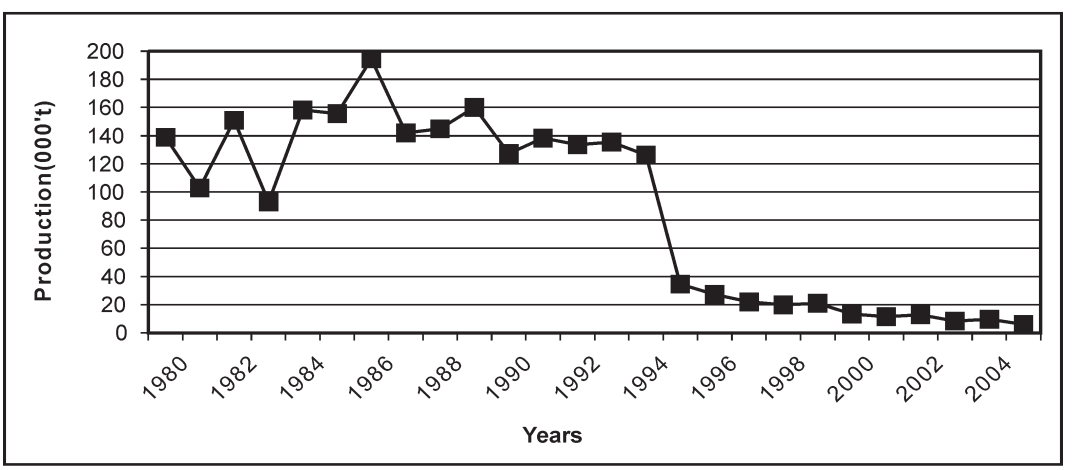
- **Varieties:** K-2, K-3, HB-3, HB-4, K-6, COH (cu) 8, GHB-526, GHB-558, ICMH-356, MLBH-267, GK-1004, PB-180, PAC-903
- **Seed rate:** 4-6 kg/ha
- **Planting pattern**: 45 X 15 cm
- **Nutrient management:** 40 kg N + 20 kg P_2O_5 (as rock phosphate) /ha + *Azospirillum*

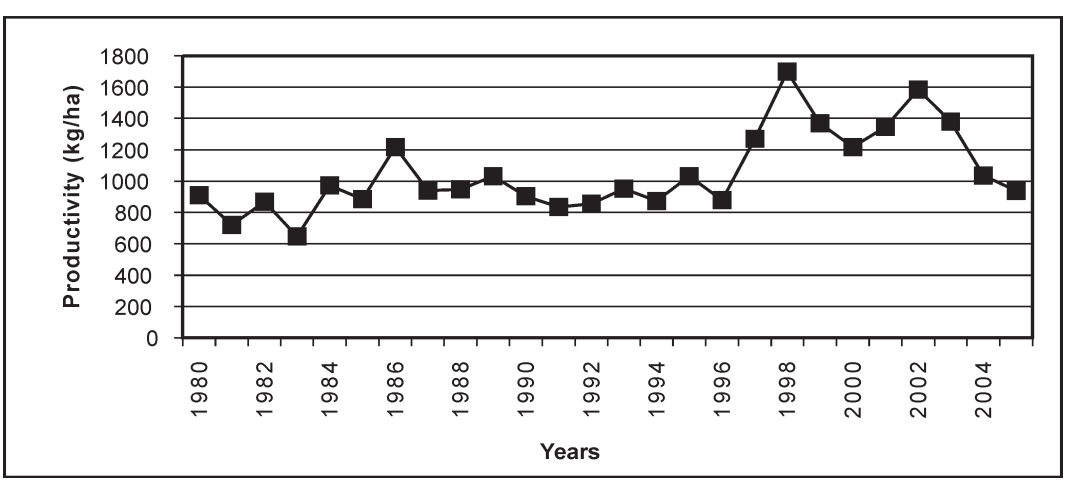
Farm Implements / tools

- Tractor drawn seed drill

Fig. 19. Trends in Area, Production and Productivity of Pearlmillet in Tamil Nadu (1980-2005)







- Bullock drawn seed drill
- Multipurpose implement

Alternate Farming Systems

- **Alley cropping**: Subabul (6 m width) + Sorghum/ Pearlmillet/ Pigeonpea,

  Subabul (6 m width) + mulching with Subabul leaves in alleys + Cotton/blackgram/Sunflower
- **Agroforestry:** Tamarind/Neem + Sorghum (K-8) Tamarind/Neem + Blackgram (C0-5)
- **Agro-horti system:** Tamarind (PKM-1) + Blackgram (K-1)
- **Silvipasture:** *Alianthus excelsa* + Blackgram, *Alianthus excelsa* + Dinanath grass
- **Fodder/ green biomass:** *Alianthas excelsa, Albizzia lebbeck, Leucaena leucocephala, Hardwickia binata, A.indica*
- **Fruit:** Mango, Sapota, Fig, Jamun and Pomegranate
- **Medicinal/ Aromatic Plants:** *Cassia aungstifolia, Palma rosa, Vetiveria zyzanoides,* Jasmine, Rose, geranium
- **Vegetables:** Okra, Bittergourd, Ridge gourd, Chilles, Brinjal, Amaranthus
- **Animal Component:** Sheep, Goat

Integrated Farming System

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

Contingent planning

- **Normal monsoon conditions**: With the onset of North east monsoon in September – October, crops like sorghum, cotton, pearlmillet, pulses and oilseeds can be sown. Sorghum (K-Tall or K-8) may be sown during the month of September
- **Delayed onset of monsoon**: If the rains the received late in October, pearlmillet (WCC-75) can be sown. Pulses like blackgram, greengram, and oilseeds like sunflower (K-1) can be grown if the rains are received later.
- **Very delayed monsoon**: Sunflower (K-1), sesame (TMV-3), Senna and Coriander can be sown upto the first week of November under very delayed monsoon conditions.
- **Early withdrawal of monsoon**: Short duration crops like pearlmillet (Co.6 and X 4) with 75 days duration and sunflower (K-1) with 65 days duration are grown.

Low runoff and medium yield gap:

UTTAR PRADESH

In Uttar Pradesh there are four districts viz. Agra, Mathura, Etawah and Aligarh under low runoff and medium yield gap region and two districts viz. Allahabad and Moradabad under low runoff and high yield gap region. The trends in area, production and productivity of pearlmillet in Uttar Pradesh (1980 - 2005) are shown in Fig. 20.

State	District	Region
Uttar Pradesh	Agra and Mathura (Ganga – Yamuna Doab) Etawah (Ganga – Yamuna Doab, Central Uttar Pradesh) Aligarh (Ganga – Yamuna Doab, Western Uttar Pradesh)	Low runoff and Medium yield gap

Agro-geographic setting	Agra	Mathura	Etawah	Aligarh
Climate	Hot semi arid	Hot semi arid	Hot moist semi arid	Hot semi arid
Soils	Inceptisols – 100%, Deep loamy alluvium - derived soils	Inceptisols – 100%, Deep loamy alluvium - derived soils	Inceptisols – 100%, Deep loamy alluvium - derived soils	Inceptisols – 100%, Deep loamy alluvium - derived soils
Annual rainfall (mm)	766	696	553	774
Potential evapotranspiration (mm)	1467	1552	1464	1530
Length of growing period (LGP) / moisture availability period (days)	90-120	90-120	120-150	60-120

Soil and water conservation

- Compartmental bunding after seedling emergence
- Contour farming
- Graded border strips
- Sowing across the slope and ridging later
- To mitigate early season drought, one extra inter cultivation along with straw mulch @ 5 t/ha is effective.
- One protective irrigation is only solution to control late season drought effect during summer.
- Deep tillage during summer and making compartmental bunding after seedlings emergence.
- Criss-cross ploughing by country plough after each effective rainfall.
- 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 the adverse effect of late season drought.

Crop management

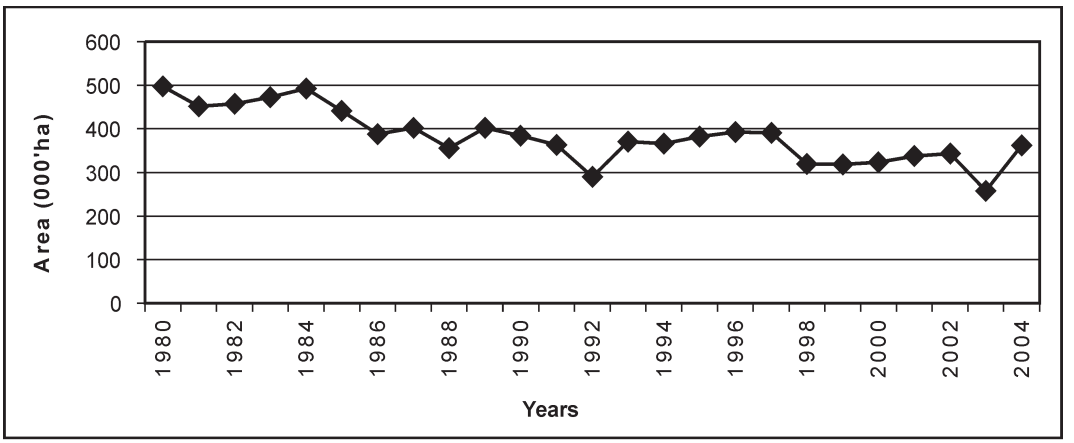
- **Hybrids** : 9330, 9444, 7688, Pusa-23, Pusa-322, HHB-67, PB-106, MBH – 110,

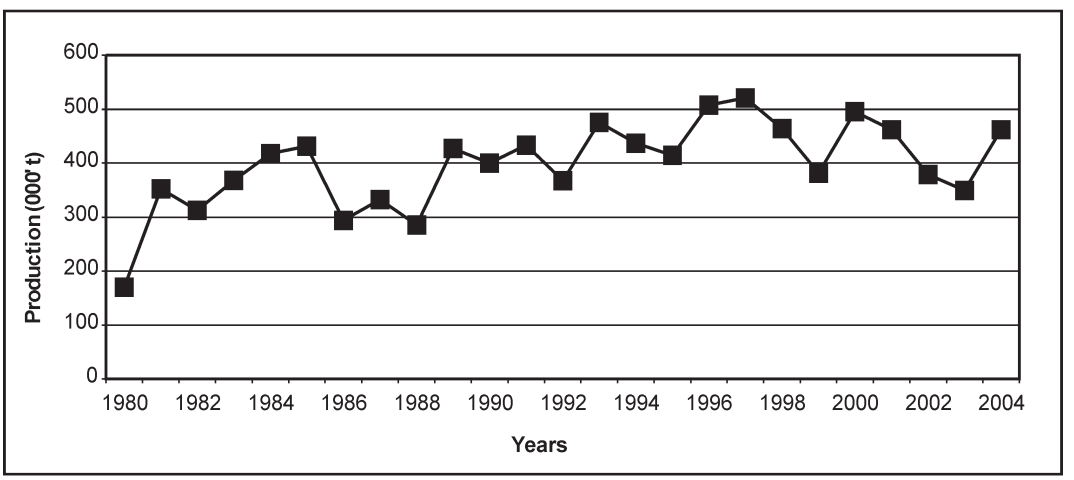
  MBH – 163, WCC – 75

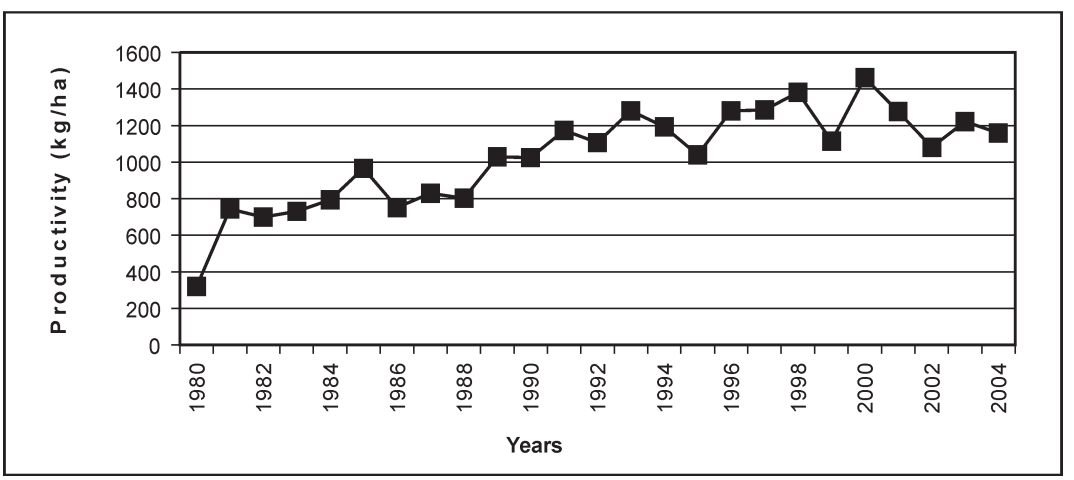
  Open pollinated varieties : Raj-171, ICTP-8203, ICMV-155

  Seed rate : Varieties 4-4.5 kg/ha

Fig. 20. Trends in Area, Production and Productivity of Pearlmillet in Uttar Pradesh (1980-2005)







- **Hybrids** : 5 – 6 kg/ha
- **Planting pattern:** 45 x 15 cm
- **Nutrient management**
  - 60 kg N and 40 kg P_2O_5/ ha. P basal and N in two splits 25% at sowing and
  - 75 % at tiller initiation
  - 60 kg N and 40 kg P_2O_5/ ha. P basal and N in two equal splits 25% at sowing and 75% at iller initiation
  - 30 kg N through FYM and 30 kg N through inorganic fertilizers
- **Some other important practices**
  - Sowing in lines in first fortnight of July
  - Extra inter cultivation along with mustard straw mulch @ 5 tones/ha increase pearlmillet yield in early season drought situation.
  - Removal of every third row increase the pearlmillet yield in late season drought
  - Transplanting of pearlmillet along with one protective irrigation is much advantageous under late seeding condition.
  - Transplanting along with one protective irrigation in late seeding condition
  - Mulching with wheat straw @5 t/ha
  - Pearlmillet + cowpea (2:1) is grown for fodder and harvested after 45 to 50 days up to end of Hugust
  - Deep tillage along with compartmental bunding + 60 kg N/ha

Suitable cropping systems

- Pearlmillet + clusterbean (2:1)
- Pearlmillet + cluster bean maloson or HG-75 (2:2)
- Greengram + pearlmillet (3:1)
- Pearlmillet + cowpea
- Pearlmillet + sesame
- Pearlmillet + cowpea (fodder) – chickpea + rapeseed mustard
- Pearlmillet + blackgram
- Pearlmillet + cowpea (fodder) – chickpea + rapeseed mustard
- Pearlmillet + rapeseed mustard
- Pearlmillet + pigeonpea (2:1)
- Pearlmillet + blackgram (2:1)
- Pearlmillet + clusterbean (2:1)

Farm Implements / tools

- Dryland weeder is quite effective and economic in controlling the weeds in both seasons.

Alternate Farming Systems

- **Agro horticulture:** Ber + greengram/ clusterbean/ cowpea for grain purpose

  Ber + pearlmillet (fodder)

- **Fodder/green biomass**: *A.indica, Leucaena, A. lebbeck, H. binata, Pongamia, C. siamea, Bauhinia*
- **Fruit:** Mango, gauva, Amla, Phalsa, Jamun, Caronda
- **Medicinal & Aromatic Plants:** *Papaver somniferum, Palma rosa, Cymbopogan flexuosus, Vetiveria zyzanoides*
- **Vegetables:** Tomato, Chillies, Brinjal, Okra, Bottle gourd, Amaranthus, Cowpea.
- **Animal Component:** Female Cattle, Female Buffaloes, Goat and Poultry

Contingent Planning

Kharif

- Under normal rainfall: Pearlmillet (Hybrids 9330, 9444, 7688, Pusa-23, Pusa-322, HHB-67, PB-106 varieties Raj-171, ICTP-8203, ICMV-155)

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

- As the monsoon progresses
- Rainfall upto end of July : Pearlmillet (Hybrids 9330, 9444, 7688, Pusa-23, Pusa-322, HHB-67, PB-106 varieties Raj-171, ICTP-8203, ICMV-155)
- 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 cluster bean, 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
- 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), and
- rapeseed mustard (TMH 1) and safflower in the order.

State	District	Region
Uttar Pradesh	Allahabad (Ganga – Yamuna Doab) Moradabad (North West Uttar Pradesh)	Low runoff and High yield gap

Agro-geographic setting	Allahabad
Climate	Hot moist semi arid
Soils	Inceptisols – 100%, Deep loamy alluvium - derived soils
Annual rainfall (mm)	1027
Potential evapotranspiration (mm)	1537
Length of growing period (LGP) / moisture availability period (days)	120-150

Soil and water conservation

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

Crop management

- **Varieties :** HHB 67-2, WCC-75, Pusa 23
- **Seed rate :** 3.75-5kg/ha
- **Planting Pattern:** 45 X 10 – 15 cm

Suitable cropping systems

- Pearlmillet - chickpea
- For fodder: Maize + cowpea-oats
- Pearl millet + cowpea – oats

Farm Implements / tools

Tool / implement	Cost/unit	Operations
Bullock drawn Malviya multi –farming machine	Rs. 2350/-	1. For field preparation 2. For seeding dryland crops and fertilizing through mechanical metering device 3. For intercultivation between two plant rows (particularly *Kharif* season crop)
Dryland weeder	Rs.70/-	For weed control between plant rows of rainfed crops

Alternate Farming Systems

- **Agro horticulture:** Guava + pigeonpea/ field pea
- **Fodder/green biomass:** *Luecaena leucocephala, Azadirachta indica, Albizzia lebbeck, Bauhinia purpurea, A. procera, B.monosperma, A.amara, D.sissoo*
- **Fruit:** Guava, Amla, Ber, Mango Bael, Jamun
- **Medicinal & Aromatic Plants:** *Papaver somniferum*, *Cymbopogan flexuosus, P. rosalea, Palma rosa, Vetiveria zyzanoides*

- **Vegetables:** Bottle gourd, Brinjal, Chillies, Cluster bean, Cowpea, round melon
- **Animal Component:** Female and male Cattle, Female Buffaloes, Sheep, Goat and Poultry

Contingent planning

- **Normal season:**

  Recommended crop and varieties along with other cultural practices should be followed as under:

- *Kharif*

Rice	:	NDR-97, NDR-118, Govind and Vandana
Maize	:	Ganga safed-2, Knachan, Jaunpuri
Pearlmillet	:	HHB 67-2, WCC-75, Pusa-23, 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 and C-306
Barley	:	DL-3, Jyoti, K-125
Rapeseed 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 resown 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 & low lands. Uplands should be considered for Pigeonpea base intercrop. If rains are delayed beyond the period but start somewhere in the first to second week of August and growing season is reduced to 60-70 days, then the cultivation of hybrid pearlmillet (BJ560, 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 either 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, linseed 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 that prevailed during kharif 1979-80 and 1987-88 season the following observations were made and appear to be worth consideration
  - Only short duration crops like grain legumes (black 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, rapeseed mustard or barley during *rabi*
  - Late season drought coinciding with reproductive phase of upland rice is frequently experienced (3/7years). If period of drought approaches 8-10 days, 25% yield could be compensated by one life saving irrigation (5cm depth)

State	District	Region
Uttar Pradesh	Moradabad (North West Uttar Pradesh)	Low run off and High yield gap

Agro-geographic setting	Moradabad
Climate	Hot semi arid, Hot dry/ moist sub humid (transitional)
Soils	Inceptisols – 100% Deep loamy alluvium - derived soils, Deep loamy to clayey alluvium - derived soils
Annual rainfall (mm)	953
Potential evapotranspiration (mm)	1418
Length of growing period (LGP) / moisture availability period (days)	60-150

Soil and water conservation

- Compartmental bunding after seedling emergence
- Contour farming
- Graded border strips
- Sowing across the slope and ridging later
- To mitigate early season drought, one extra inter cultivation along with straw mulch @ 5 t/ha is effective.
- One protective irrigation is only solution to control late season drought effect during summer.
- Deep tillage during summer and making compartmental bunding after seedlings emergence.
- Criss-cross ploughing by country plough after each effective rainfall.
- 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 the adverse effect of late season drought.

Crop management

- **Varieties :** WCC-75, Pusa 23

  Hybrids : MBH – 110, MBH – 163
- **Seed rate :** Hybrids - 4-4.5 kg/ha

  Varieties : 3. 5 kg/ha
- **Planting pattern:** 45 X 15 cm
- **Nutrient management :**
  - 60 kg N and 40 kg P_2O_5/ ha. P basal and N in two splits 25% at sowing and 75% at tiller initiation
  - 60 kg N and 40 kg P_2O_5/ ha. P basal and N in two equal splits at sowing and tiller initiation
  - 30 kg N through FYM and 30 kg N through inorganic fertilizers
- **Some other important practices**
  - Sowing in lines
  - Extra inter cultivation along with mustard straw mulch @ 5 tons/ha increase pearlmillet yield in early season drought situation.
  - Removal of every third row increase the pearlmillet yield in late season drought
  - Transplanting of pearlmillet along with one protective irrigation is much advantageous under late seeding condition.
  - Transplanting along with one protective irrigation in late seeding condition

Suitable cropping systems

- Pearlmillet + clusterbean (2:1)
- Pearlmillet + greengram
- Pearlmillet + cowpea
- Pearlmillet + sesame
- Pearl millet – chickpea
- Pearlmillet + pigeonpea (2:1)
- Pearlmillet + blackgram (2:1)

Farm Implements / tools

- Dryland weeder is quite effective and economic in controlling the weeds in both seasons.

Alternate Farming Systems

- **Fodder/green biomass**: *A.indica, Leucaena, A. lebbeck, H. binata, Pongamia, C. siamea, Bauhinia*
- **Fruit:** Mango, guava, Amla, Phalsa, Jamun, Caronda
- **Medicinal & Aromatic Plants:** *Papaver somniferum, Palma rosa, Cymbopogan flexuosus, Vetiveria zyzanoides*

- **Vegetables:** Tomato, Chillies, Brinjal, Okra, Bottle gourd, Amaranthus, Cowpea.
- **Animal Component:** Female Cattle, Female Buffaloes, Goat and Poultry

Contingent Planning

Kharif

- **Under normal rainfall**: Pearlmillet (WCC-75, Pusa-23, Proagro-9402), pigeonpea (UPAS-120), greengram (K-851), Clusterbean (RGC-197)
- **As the monsoon progresses**
- Rainfall upto end of July : Pearlmillet (WCC-75, Pusa-23) intercroppied with cowpea and sesame
- 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 (Pusa-23)
- 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) and taramira (TMH-1) and safflower in the order.

Cultural practices like shallow intercultural to eradicate weeds, maintain soil mulch to conserve soil moisture, application of surface mulch, thinning of crops by removing alternate rows as in pearlmillet and recycling of stored runoff water are generally resorted to.

Prioritised cultural option for rainfed pearlmillet based production system

State	District	Prioritised Options	Avg yield (kg/ha)	Expected yield (kg/ha)
Gujarat	Surendranagar	Efforts for wide spread adoption of improved varieties, crop management technologies. *In-situ* soil conservation technologies	606	727 to 758
	Ahmedabad	Better water management techniques including surface drainage along with improved management techniques to increase productivity	698	838 to 873
	Rajkot	Adoption of improved management practices including high yield cultivars, *in situ* water management techniques	541	650 to676
	Amreli, Bhavnagar, Junagadh	Efforts for wide spread adoption of improved varieties, crop management technologies. *In-situ* soil conservation technologies	1219	1402 to 1463
Haryana	Gurgaon	Efforts for wide spread adoption of improved varieties, crop management technologies. *In-situ* soil conservation technologies	541	650 to676
Karnataka	Belgaum	Crop diversification	334	400 to 418
	Bijapur	Efforts for wide spread adoption of improved varieties, crop management technologies. *In-situ* soil conservation technologies	606	727 to 758
	Gulbarga, Raichur	Adoption of improved management practices including high yield cultivars, *in situ* water management techniques	541	650 to676
Madhya Pradesh	Morena	Adoption of high yield cultivars, water harvesting for supplement irrigation, pest and disease management techniques for further increase in yield	1062	1221 to 1274
Maharastra	Sangli	Adoption of improved management practices including high yield cultivars, *in situ* water management techniques	331	397 to 414
	Satara	Crop diversification	334	400 to418
	Nasik	Efforts for wide spread adoption of improved varieties, crop management technologies. *In-situ* soil conservation technologies	606	727 to758
	Ahmednagar, Aurangabad, Beed, Pune	Better water management techniques including surface drainage along with improved management techniques to increase productivity	698	838 to873
	Dhule	Efforts for wide spread adoption of improved varieties, crop management technologies. *In-situ* soil conservation technologies	868	998 to1042
	Jalna	Better water management techniques including surface drainage along with improved management techniques to increase productivity	779	935 to974
	Jalgaon	Adoption of high yield cultivars, water harvesting for supplement irrigation, pest and disease management techniques for further increase in yield	1062	1221 to 1274

Rajasthan	Jaipur	Better water management techniques including surface drainage along with improved management techniques to increase productivity	698	838 to 873
	Alwar, Bharatpur, Dholpur, Sawai madhopur	Efforts for wide spread adoption of improved varieties, crop management technologies. In-situ soil conservation technologies	868	998 to 1042
Tamilnadu	Tiruchirapalli	Adoption of improved management practices including high yield cultivars, *in situ* water management techniques	541	650 to 676
	S.Arcot	Adoption of high yield cultivars, water harvesting for supplement irrigation, pest and disease management techniques for further increase in yield	1062	1221 to 1274
Uttar Pradesh	Agra, Aligarh, Etah, Mathura	Efforts for wide spread adoption of improved varieties, crop management technologies. *In-situ* soil conservation technologies	1219	1402 to 1463
	Allahabad, Moradabad	Adoption of high yield cultivars, water harvesting for supplement irrigation, pest and disease management techniques for forther increase in yield	1062	1221 to1274
West Bengal	Buduan	Adoption of high yield cultivars, water harvesting for supplement irrigation, pest and disease management techniques for further increase in yield	1062	1221 to 1274

FINGERMILLET BASED PRODUCTION SYSTEM

Fingermillet (*Eleusine coracana* L.), is the third most important millet grown in many states of India under diverse situation of soils, temperature and rainfall. It is popularly known as ragi in India. It is also known as mandua, ragalu, nagli, kapai and madua in different parts of the country. It is extensively grown in Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Bihar, Jharkhand, Bastar region of Chhatisgarh, Gujarat and Maharashtra and in the hilly regions of Uttarkhand and Himachal Pradesh. This is an important staple food crop in southern parts of Karnataka. The height of cultivars varies from 40 to I00 cm and the ear length ranges from 3 to 13 cm. The colour of grains varies from white through orange-red, deep brown and purple, to almost black. The seed coat of finger millet is generally copper brown in color and contains large proportion of phytochemicals and pigments. However, different grades of brown and white coloured varieties of the millet are also cultivated. Polyphenols are the important phytochemicals having the neutraceutical qualities. The grains are smaller than those of pearlmillet and the mean 1000-seed weight is about 2.6 g.

Fingermillet is grown as a rainy season crop from June to November – December, using long duration varieties and as a (cold) post – rainy season crop, from October - November, using early types. Liberal sheep and cattle manure is applied along with green manures such as cowpea or sunhemp, and oil cakes. Fingermillet is harrowed and weeded at intervals of fortnight from 15-20 days of sowing. It matures in about 95 - 135 days after sowing, depending on variety, season, rainfall and soil moisture holding capacity. Rainfed crops are cut close to ground. Stalks are allowed to dry for a day or two in field, and then bundled and stacked for about 2 months before threshing. To separate the grains, dried ear heads are beaten with sticks. Sheaves are trodden by bullocks or crushed by stone rollers. The average grain yield of the rainfed crop ranges from 1.0 to 1.5 t/ha. The fodder yield ranges from 3-9 t/ha in the case of the late duration cultivars.

Fingermillet is grown in 1.89 mha in 346 districts out of which 1.70 mha is rainfed. About 85% of the rainfed area (1.03 mha) is in 12 districts.

Item	No. of districts	Area under fingermillet ('000 ha)	Area under rainfed fingermillet ('000 ha)	Gross cropped area ('000 ha)	Yield (kg/ha)
Sixteen states	346	1891	1697	1678.68	406
85% rainfed fingermillet area in the states	12	1124	1031	1047.5	1150

The trends in area, production and productivity of fingermillet in India (1980 - 2005) are shown in Fig. 21.

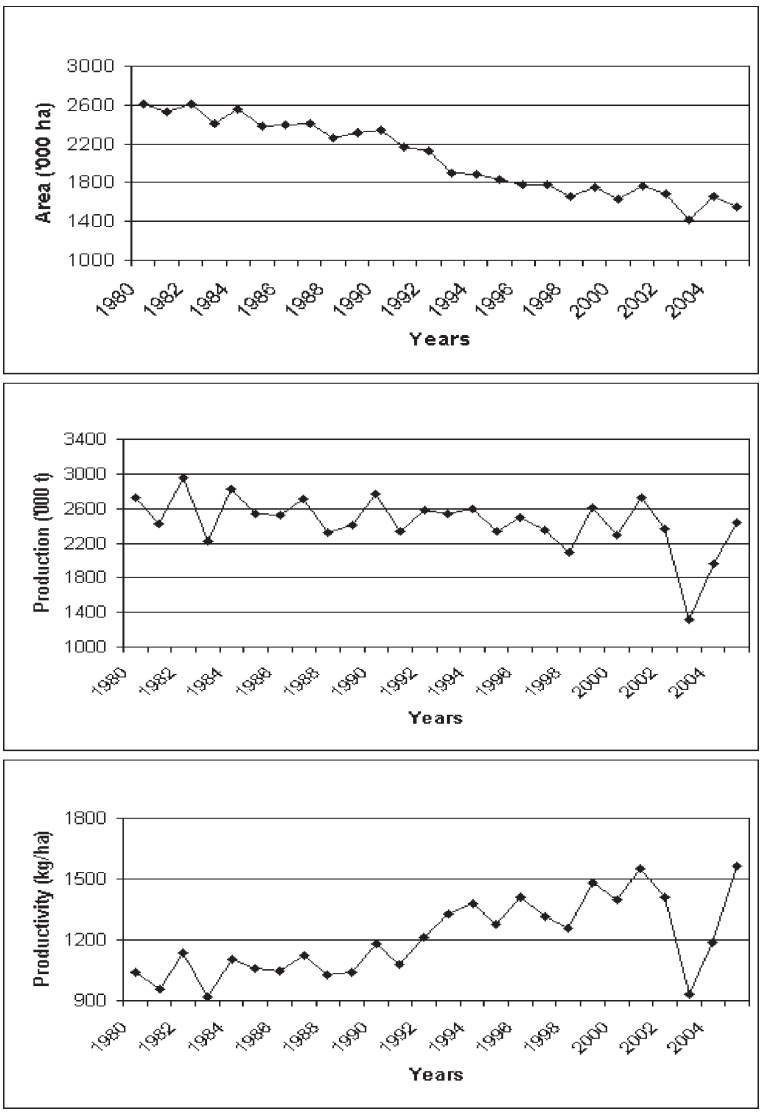
The trends in area, production and productivity for different states are given in the following table :

Area	Production	Productivity	State
Decreasing	Decreasing	Stable	Orissa
Stable	Stable	Stable	Maharastra
Stable	Stable	Increasing	Andhra Pradesh
Decreasing	Decreasing	Decreasing	Karnataka

Mysore, Mandya, Koraput, Ganjam and Kalahandi support the traditional fingermillet zone where both yield and area growth rates are stagnant. In other districts the effect of technology is visible with production increase or maintanence despite variation in area.

Common intercrops grown with fingermillet are fieldbean (*Lablab purpureus*), pigeonpea (*Cajanus cajan*), cowpea (*Vigna sinensis*), niger (*Guizotia abysinnica*), fodder sorghum (Sorghum bicolor) groundnut (*Arachis hypogea*), castor bean (*Ricinus communis*) and other cereals. Mixing of nine crops (Akkadi) is a common practice in Karnataka. The popular cropping systems are fingermillet-groundnut: fingermillet - pigeonpea/horsegram: fingermillet – cowpea or cowpea – fingermillet.

Fig. 21. Trends in Area, Production and Productivity of Fingermillet in India (1980-2005)



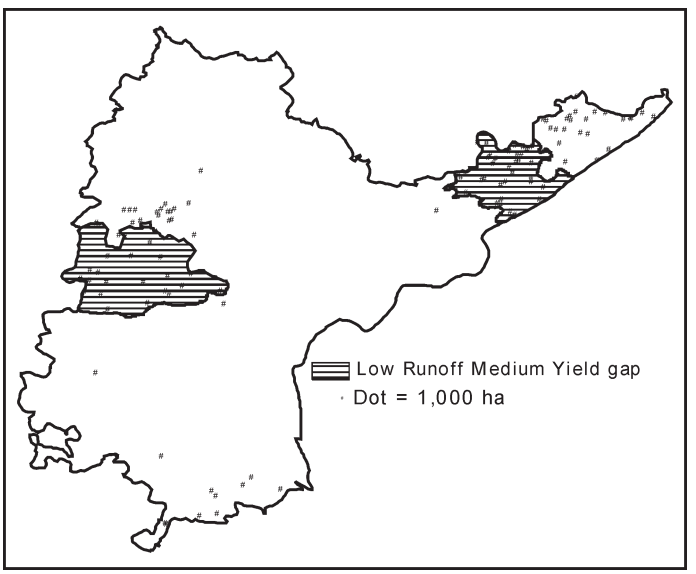
The details on associated crops and livestock arrived after clustering in the cropping zone are:

Crops	Animals	Districts
Rice	Sheep	Visakapatanam, Mahaboobnagar, Mysore
Fingermillet	Female Cattle	Shimoga, Nasik, Pune, Kolhapur, Ganjam
Horsegram	Male Buffalo	Kalahandi, Koraput
Fingermillet	Sheep	Kolar, Mandya
Horsegram	Female Cattle	
	Male Buffalo	

The Recommendations for this production system are given state and district-wise in alphabetical order.

ANDHRA PRADESH

In Andhra Pradesh there are two districts viz. Mahaboobnagar and Visakhapatnam under low runoff and medium yield gap region. The trends in area, production and productivity of fingermillet in Andhra Pradesh (1980 - 2005) are shown in Fig. 22.

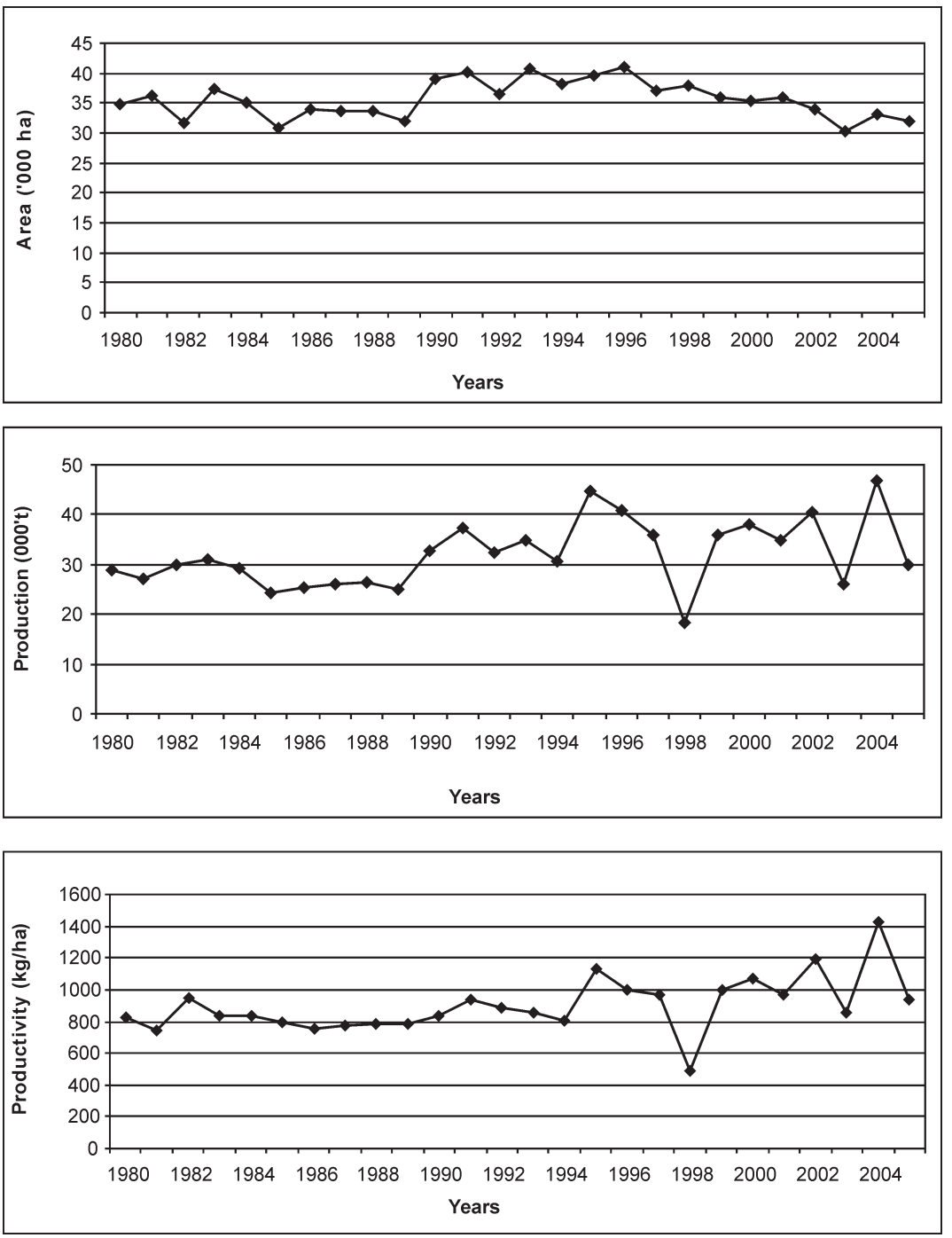


Recommendations details follow:

State	District	Region
Andhra Pradesh	Mahaboobnagar Visakhatpatnam	Low runoff and Medium yield gap

Agro-geographic setting	Mahaboobnagar	Visakhatpatnam
Climate	Hot moist semi arid	Hot (moist/ dry) sub humid
Physiography	North Telangana Plateau	Eastern ghats and North Coastal Andhra Pradesh
Soils	Vertisols – 40%; Vertic soils – 20%; Sandy Alfisols – 40%	Orthids – 50%; Sandy Alfisols – 50%
	Deep loamy, clayey mixed red and black soils	Medium to deep loamy red and lateritic soils, deep loamy to clayey coastal and deltaic-alluvium derived soils
Annual rainfall (mm)	792	975
Potential evapotranspiration (mm)	1678	1480
Length of growing period (LGP) / moisture availability period (days)	120-150	180-210

Fig. 22. Trends in Area, Production and Productivity of Fingermillet in Andhra Pradesh (1980-2005)



Soil and water conservation

Mahaboobnagar

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

Visakhapatnam

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

Crop management

Visakhapatnam

- **Varieties:** Kalyani, Godavari, AKP-2, Simhadri, Ratnagiri, Gautami, Padmavati, Saptagiri, Sharada, Ratnagiri
- **Seed rate:** 8-10 kg/ha
- **Planting pattern:** 22.5 x 10 cm or 22.5 x 15 cm
- **Intercropping system:** Intercropping of pigeon pea (long duration type) with finger millet in 8:2 proportion found profitable.
- **Nutrient management:** FYM 10 t /ha + 40 kg N + 20 kg P_2O_5 + 20 kg K_2O /ha
- **Some other important practices**
- Sowing: *kharif* – July – August
- Seed treatment with Thiram 3 g/kg seed

Farm implements/ tools

Mahaboobnagar

- CRIDA Groundnut planter (four row)
- Bullock drawn two-row sweep cultivator
- Modified two-row blade harrow
- Bullock drawn country plough attached with Pora tube

Visakhapatnam

- Hand Hoe

Alternate farming systems

Mahaboobnagar

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

- **Silvipastoral system:** *Leucaena leucocephala + Stylosanthes hamata, Leucaena leucocephala + Cenchrus ciliaris*
- **Alley cropping:** *Leucaena leucocephala + sorghum/ Pearlmillet, Gliricidia sepium + sorghum/pearlmillet*
- **Agro horti system:** Mango + short duration pulses
- **Fruit:** Mango, Ber, Custard apple, Guava, Pomegranate, Amla
- **Fodder/green biomass:** *Luecaena leucocephala. Azadirachta indica, Albizia lebbeck, Bauhinia purpurea, A. procera, Butea monosperma, A.amara, Delbergia sissoo*
- **Medicinal and aromatic plants:** *Catharanthus roseus, Cassia angustifolia, Aloe barbadensis, Withia somnifera, Cymbopogan martini, Cymbopogan flexuosus, Al Psoralea, Palma rosa, Vetiveria zyzanoides*
- **Dye yielding plants:** *Lawsonia inermis, Hibiscus sabdariffa, Tagetus errecta, Indigofera tinctoria, Annato*
- **Other economic shrubs:** Curry leaf, Jatropha, Soapnut
- **Animal component:** Female cattle, Female Buffaloes, Male Cattle, Sheep and Goat
- **Other enterprises:** Sericulture, Poultry

Visakhaptanam

- **Fodder/green biomass***: P.pinnata, Albizzia sps, Cassia siamea, Grevellea robusta, Delbergia sissoo*, *Azadirachta indica*
- **Fruit:** Mango, Jackfruit, Guava, Lime
- **Medicinal and aromatic plants:** *Vetiveria zyzanoides, Cymbopogan flexuosus, Palma rosa, Solanum viarum,* Cinnamon, Citronella java
- **Vegetables:** Bottle gourd, Brinjal, Ridge gourd, Watermelon, Long melon, Bitter gourd, Tomato
- **Animal component:** Female and male cattle, Goat

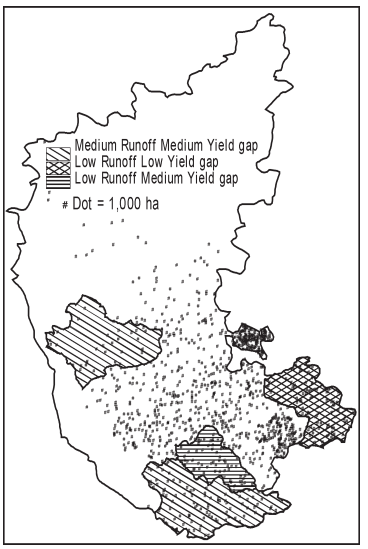
Contingent planning

Mahaboobnagar

- **June:**
  - Sole crop: Sorghum (CSH-5, CSH-6, CSH-9) pearlmillet (MBH-110)
  - Intercrop: Sorghum + pigeonpea (2:1) / pearlmillet + pigeonpea (2:1) in 45 cm row spacing. Pigeonpea duration of 150- 180 days may be used.
- **July:**
  - Sole castor (Aruna, GCH-4)
  - Sole fingermillet
  - Bunch variety of groundnut (TMV-2, JL-24)
  - Intercrop: Maize (DHM-101, Ganga-5) + pigeonpea (2:1) at 50 cm spacing.
- **August:**
  - Sole setaria (H-1, Arjuna) for grain to poultry feed and straw for fodder
  - Castor (Aruna, GCH-4) with increased seed rate (15 kg/ha)

KARNATAKA

In Karnataka there is one district viz. Kolar under low runoff and low yield gap region, one district viz. Mandya under low runoff and medium yield gap region and two districts viz. Mysore and Shimoga under medium runoff and medium yield gap region. The trends in area, production and productivity of fingermillet in Karnataka (1980 - 2005) are shown in Fig. 23.



Recommendations details follow:

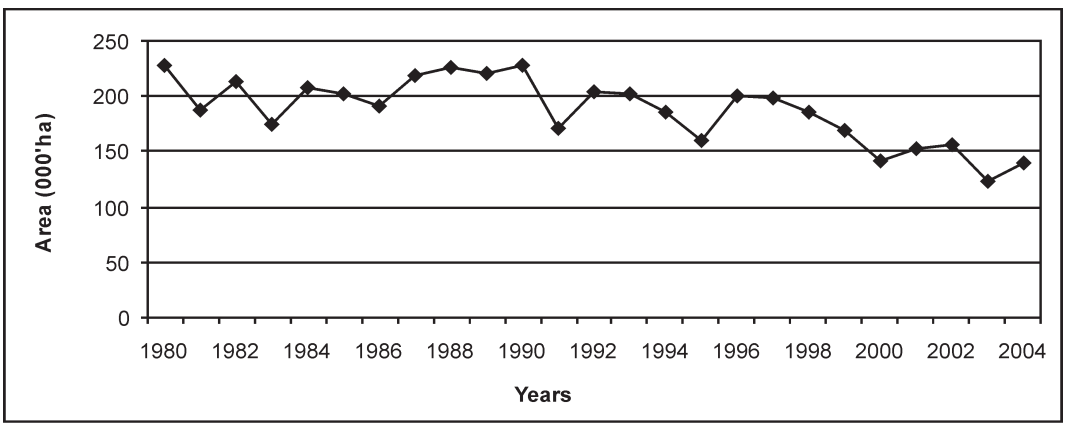
State	District	Region
Kolar	*Region*	Low runoff and Low yield gap

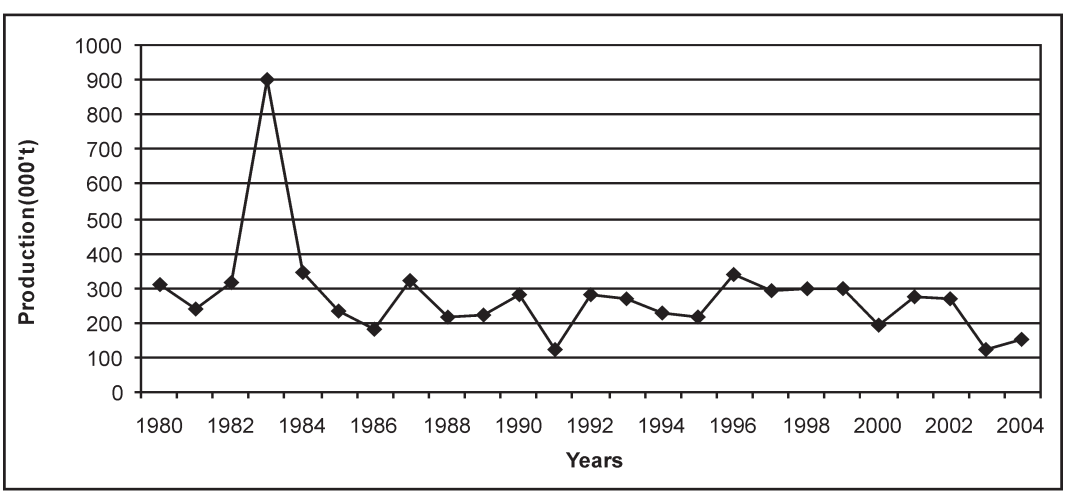
Agro-geographic setting	Kolar
Climate	Hot moist semi arid
Physiography	South Karnataka - Central Karnataka Plateau
Soils	Sandy Alfisols – 100% Medium to deep red loamy soils
Annual rainfall (mm)	734
Potential evapotranspiration (mm)	1562
Length of growing period (LGP) / moisture availability period (days)	120-150

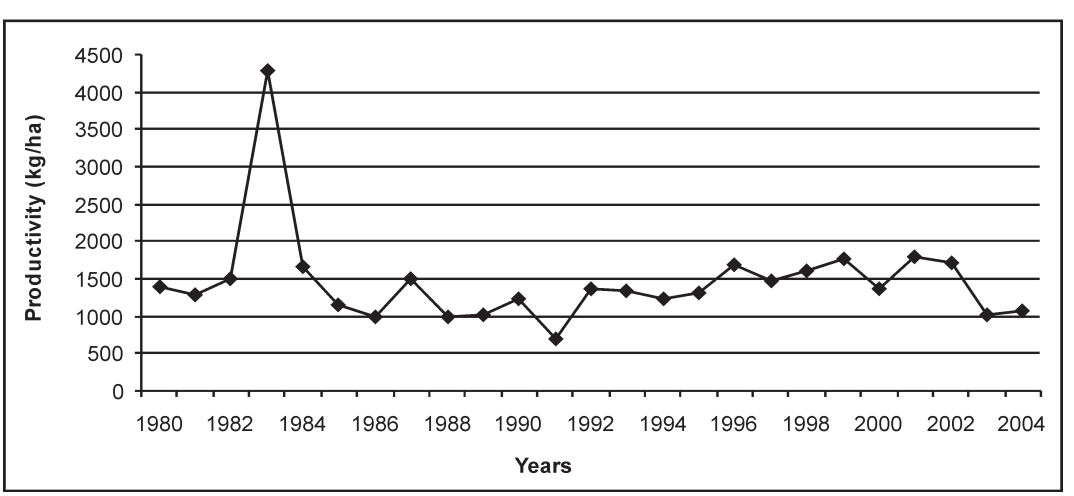
Soil and water conservation

- ***In-situ* conservation practices:**
  - Opening a conservation furrow in between the paired rows of pigeonpea or maize for better moisture conservation.
  - Graded ridge and furrows are made on 0.2 to 0.4 percent grade for better conservation of moisture as well as safe disposal in maize cultivation.

Fig. 23. Trends in Area, Production and Productivity of Fingermillet in Karnataka (1980-2005)







- Fall ploughing to a depth of 15-30 cm for better infiltration of rainwater during onset of rains.
- Deep tillage to a depth of 25-30 cm using mould board plough to reduce the weed incidence and increase soil moisture storage for sunflower and maize crops.
- Crop cultivation across the slope with vetiver/ pennisetum grass as live barrier at 0.5 m vertical interval to check the velocity of runoff and better moisture conservation and availability for a longer period for fingermillet/ groundnut/ maize/ sunflower crops.

- **Long-term conservation practices:**
  - Construction of contour bunds with a cross section of 0.54 m^2 to control and conserve runoff.
  - Construction of graded bunds by providing 0.2 to 0.4 per cent grade with a cross section of 0.36 m^2 for safe disposal of excess runoff.
  - Graded boarder strips with a gradient of 0.1 to 0.5 per cent to fit into the local topography and hydrographic features.
  - Broad based bunds of 1.5 m^2 cross section on contour with 1 m vertical interval for better rainwater conservation.
  - Reduced contour bunds (0.36 m^2) in combination with vegetative live barriers for effective conservation of rainwater in low rainfall areas (< 600 mm)

Crop management

- **Varieties:** L-5, Indaf – 8, MR – 1, MR – 6, GPU – 28, PR – 102, HR – 911, GPU – 26, Indaf – 5, Indaf - 9
  - Indaf – 8 for early in July
  - PR-202 for early August sowing
  - Indaf – 5 or Indaf – 9 for late sowing
  - June sowing: L – 5; MR – 1; MR – 6.
  - July 1st fortnight sowing: L – 5; MR – 1; MR – 6.
  - July 2nd fortnight sowing: Indaf – 8; L – 5; HR 911; PR – 202.
  - August 1st fortnight sowing: GPU – 28; GPU – 26; PR – 202.
  - August 2nd fortnight sowing: GPU – 26; GPU – 48; Indaf – 9.
- **Seed rate:** 10 kg/ha
- **Planting pattern:** 30 x 7.5 cm / 22.5 cm x 10 cm. Spacing is same for drilling and transplanting
- **Nutrient management:** 10 t FYM/ha + 40 kg N + 50 kg P_2O_5 + 25 kg K_20 /ha**.** N in 2 equal splits, 1/2 at sowing or drilling and remaining 1/2 at tillering initiation; P and K basal placement
- **Some other important practices**
  - August sowing – short duration fingermillet, transplant fingermillet 10-12 cm deep ploughing
  - For establishing fingermillet in July – drilling seeds using seed drill / seed cum fertilizer drill is to be done
  - For late establishment – Transplanting the seedlings is essential

Suitable cropping systems

- Cowpea- fingermillet
- Greengram- fingermillet
- Sesame- fingermillet
- Fodder Sorghum – Transplanted fingermillet
- Pigeonpea paired rows - finger millet (10:2)
- Fingermillet + field bean (8:1)
- Fingermillet + pigeonpea (10:2) with conservation furrow between pigeonpea rows
- Fingermillet + soybean (1:1)
- Paired rows of pigeonpea followed by 8 rows of fingermillet with a furrow inbetween pigeonpea rows. Planting of pigeonpea in May and fingermillet in July.

Farm implements/ tools

- **Bullock drawn seed-sum-fertilizer drill (fingermillet):** Bullock drawn manual operation for fingermillet seeding and fertilizer (hand metered) application (Rs. 1500/- per unit)
- **Multi-furrow opener:** Opening furrows for hand seeding of different crops (Rs. 1300/- per unit)
- **Bent tyne hoe:** Intercultural operation for finger millet (Rs. 350/- per unit)
- **Duck foot hoe:** Intercultural operation for finger millet and groundnut for moisture conservation (Rs. 350/- per unit)
- **Crust breaker:** For breaking the crust to facilitate smooth emergence of the seedling in finger millet and groundnut (Rs. 500/- per unit)
- For opening furrows at 3.3 m interval simultaneously with sowing the seeds of finger millet, the newly designed seed drill with furrow opener is a convenient implement.
- Five coultered, 30 cm row spaced finger millet seed-cum-fertilizer drills should be used for sowing finger millet.

Alternate farming systems

- **Fodder/green biomass:** Casuarina and Silver Oak are better suited than other tree species like eucalyptus, *Azadirachta indica*, *Leucaena, Acacia* etc.
  Faidherbia albida is more suitable for planting on bunds (E-W direction) in micro-watershed.
  Stylosanthes hamata is most suitable. *Stylasanthes scabra* should be adopted for gravelly shallow soils with low rainfall.

  Acacia auriculiformis, Cassia siamea, Dalbergia sissoo, subabul and amla are more suitable and promising than other deep-rooted high water intensive tree species under high gradient non-arable lands with shallow soils and rock out crops. For better establishment, trench method of planting is better than pit method.

  Bamboo, Jambulina, pongamia, *Azadirachta indica*, *Albizia lebbeck*, peepal, and ficus species can be planted in the catch pits and pockets of deep soil.

  Grasses like *Pennisetum pedicellatum or Cenchrus ciliaris* and legumes like *Microtelium axillaries* are suitable forage species.

Leucaena leucocephala, Albizzia lebbeck, Dalbergia sissoo, Azadirachta indica, Pongamia, Cassia siamea

- **Fruit:** In suit grafting/ budding of fruits trees like mango and ber found to be more economical than using grafted plants. Custard apple, Jack and tamarind were other species suitable to wastelands.

  Mango, Phylanthus and Jambulina performed better in the non-arable land.

  Mango, pomegranate, sapota, guava, custard apple, jamun.

- **Medicinal and aromatic plants:** *Catharanthus roseus, Cassia angustifolia, Solanum viarum, Dioscorea, Geranium, Pogostemon patchouli,* Jasmine
- **Vegetables:** Tomato, chillies, okra, watermelon, bitter gourd, drum stick, brinjal, bottle gourd.
- **Animal Component:** Female cattle, male cattle, female buffaloes, sheep
- **Other enterprises:** Sericulture, piggery, goat rearing, rabbit rearing.

Contingent planning

- **Second fortnight of April**
  - Double cropping: Sesame or greengram or cowpea
- **First fortnight of May**
  - Monocropping: Pigeonpea
  - Sequence cropping: Sesame, cowpea, greengram, blackgram, fodder maize, fodder pearlmillet, fodder sorghum.
- **Second fortnight of May**
  - Monocropping: Pigeonpea
  - Sequence cropping: Sesame, cowpea, greengram, blackgram, fodder maize, fodder pearlmillet, fodder sorghum.
- **First fortnight of June**
  - Monocropping: Long duration fingermillet, pigeonpea, maize, groundnut
  - Sequence cropping: Fodder maize, fodder sorghum, fodder pearlmillet, cowpea
- **Second fortnight of June**
  - Monocropping: Long duration fingermillet, pigeonpea, maize and groundnut
  - Sequence cropping: Sowing of chilli nursery
- **First fortnight of July**
  - Monocropping: Groundnut, long duration finger millet
  - Sequence cropping: Sowing of chilli nursery
- **Second fortnight of July**
  - Monocropping: Groundnut, long/medium duration fingermillet
  - Sequence cropping: Sowing of chilli nursery
- **First fortnight of August**
  - Monocropping: Cowpea, horsegram, short duration finger millet, transplanting chilli

- Sequence cropping: Cowpea, horsegram, short duration finger millet, transplanting chilli.
- Sowing of chilli nursery and short duration fingermillet.

- **Second fortnight of August**
  - Monocropping: Short duration finger millet, transplanting of medium and long duration fingermillet. Transplanting chilli, cowpea, horsegram
  - Sequence cropping: Short duration fingermillet, transplanting of medium and long duration fingermillet, transplanting chilli, cowpea, horsegram, fodder crops (maize, pearlmillet, sorghum)
- **First fortnight of September**
  - Monocropping: Horsegram or transplanting of short duration finger millet or chilli (with protective irrigation)
  - Sequence cropping: Horsegram or transplanting of short duration finger millet or chilli (with protective irrigation)

Alternate/ Contingency crop production practices for drought mitigation:

- Dry seeding in finger millet, sorghum, pigeonpea and castor when monsoon is delayed. For crops with big seeds and less seed rate, like pigeonpea, pelletisation of seed is to be done before dry sowing.
- Maintain optimum plant population by thinning.
- Repeated intercultivations coupled with weeding and weed mulching.
- Preventive measures against pests and diseases.
- Double split top dressing.
- Controlled grazing by animals to reduce excess vegetative growth and to minimize transpiration in fingermillet and horsegram

State	District	Region
Karnataka	Mandya	Low runoff and Medium yield gap

Agro-geographic setting	Mandya
Climate	Hot moist semi arid
Physiography	South Karnataka Central Karnataka Plateau
Soils	Sandy Alfisols – 100%
	Medium to deep red loamy soils
Annual rainfall (mm)	674
Potential evapotranspiration (mm)	1539
Length of growing period (LGP) / moisture availability period (days)	120-150

Soil and water conservation

- ***In-situ* conservation practices:**
  - Opening a conservation furrow in between the paired rows in pigeonpea and maize for better moisture conservation.
  - Graded ridge and furrows are made on 0.2 to 0.4 percent grade for better conservation of moisture as

well as safe disposal .

- Fall ploughing to a depth of 15-30 cm. for better infiltration of rainwater during onset of rains.
- Deep tillage to a depth of 25-30 cm. using mould board plough to reduce the weed incidence and increase soil moisture storage for sunflower and maize crops.
- Crop cultivation across the slope with Vetiver/ pennisetum grass as live barrier at 0.5 m vertical interval to check the velocity of runoff and better moisture conservation and availability for a longer period for fingermillet/groundnut/maize/sunflower crops.
- More emphasis on *in situ* water conservation
- Reducing soil crusting problem
- Conservation furrows at 3.3 m interval
- Farm pond size of 250 m^3 plastered both sides and bottom with cement + sandy clay soils (1:8)
- Opening furrows on 0.2 to 0.4 slope
- Summer tillage
- The existing bund itself could be modified to act as graded bund by internal land smoothening Open end contour bunds (0.8 m^2) or graded bunds (0.36 m^2) on a slope of 0.2 to 0.4%. Waterways are viable with outlets.
- Developing deeper soil (<45 cm) into graded border strips of 10-12 m width on a gradient of 0.2 to 0.4 percent along the length
- Alleviation of crust is possible with the addition of 10 t FYM/ha, 5 ton maize residue/ha and 25 sand t/ha

- **Long term conservation practices:**
  - Construction of contour bunds with a cross section of 0.54 m^2 to control and conserve runoff.
  - Construction of graded bunds by providing 0.2 to 0.4 per cent grade with a cross section of 0.36 m^2 for safe disposal of excess runoff.
  - Graded boarder strips with a gradient of 0.1 to 0.5 per cent to fit into the local topography and hydrographic features.
  - Broad based bunds of 1.5 m^2 cross-sections on contour with 1 m vertical interval for better rainwater conservation.
  - Reduced contour bunds (0.36 m^2) in combination with vegetative live barriers for effective conservation of rainwater in low rainfall areas (< 600 mm)

Crop management

- **Varieties:** L-5, Indaf–8, MR–1, MR – 6; GPU–28, PR–102, HR–911, GPU–26, Indaf–5, Indaf - 9
  - Indaf – 8 for early in July
  - PR-202 for early August sowing
  - Indaf – 9 and GPU 48 for late sowing
- **Seed rate:** 10 kg/ha
- **Planting pattern:** 30 x 10 cm. Spacing is same for drilling and transplanting
- **Nutrient management:** 10 t FYM/ha + 50 kg N + 50 kg P_2O_5 + 25 kg K_20 /ha. N in 2 equal splits, 1/3 at

sowing or drilling and 2/3 at tillering initiation; P and K basal placement

Some other important practices

- August sowing – short duration fingermillet, transplanted fingermillet 10-12 cm depth – ploughing
- For establishing fingermillet in July – seed drilling is to be done
- For late establishment – transplanting the seedlings is essential

Suitable cropping systems

- Cowpea- fingermillet
- Greengram- fingermillet
- Blackgram - fingermillet
- Sorghum – Transplanted fingermillet
- Pigeonpea paired rows-fingermillet (10:2)
- Finger millet-field bean
- Fingermillet + pigeonpea (10:2) with conservation furrow between pigeonpea rows
- Fingermillet + soybean (1:1)
- Paired rows of pigeonpea followed by 8 rows of fingermillet with a furrow between pigeonpea. Planting of pigeonpea in May and fingermillet in July.

Farm implements / tools

- **Bullock drawn seed-sum-fertilizer drill (fingermillet):** Bullock drawn manual operation for fingermillet seeding and fertilizer (Hand metered) application (Rs. 1500/- per unit)
- **Multi-furrow opener:** Opening furrows for hand seeding of different crops (Rs. 1300/- per unit)
- **Bent Tyne hoe:** Intercultural operation for fingermillet (Rs. 350/- per unit)
- **Duck foot hoe:** Intercultural operation for fingermillet and groundnut for moisture conservation (Hand metered) (Rs. 350/- per unit)
- **Crust breaker:** For breaking the crust to facilitate smooth emergence of the seedling in finger millet and groundnut (Rs. 500/- per unit)
- For opening furrows at 3.3 m interval simultaneously with sowing the seeds of finger millet, the newly designed seed drill with furrow opener is a convenient implement.
- Five coultered, 30 cm row spaced finger millet seed-cum-fertilizer drills should be used for sowing finger millet.

Alternate farming systems

- **Fodder/green biomass:** *Casuarina* and silver oak are better suited than other tree species like eucalyptus, *azadirachta indica, leucaena, acacia* etc.

  Faidherbia albida is more suitable for planting on bunds (E-W direction) in micro-watershed.

  Stylosanthes hamata is most suitable. *Stylasanthes scabra* should be adopted for gravelly shallow soils

with low rainfall.

Acacia auriculiformis, Cassia siamea, Dalbergia sissoo, subabul and amla are more suitable and promising than other deep-rooted high water intensive tree species under high gradient non-arable lands with shallow soils and rock out crops. For better establishment, trench method of planting is better than pit method.

Bamboo, jambulina, pongamia, *Azadirachta indica*, *Albizzia lebbeck*, peepal, and ficus species can be planted in the catch pits and pockets of deep soil.

Grasses like *Pennisetum pedicellatum or Cenchrus ciliaris* and legumes like *Microtelium axillaries* are suitable forage species.

Leucaena leucocephala, Albizzia lebbeck, Dalbergia sissoo, Azadhiracta indica, Pongamia, Cassia siamea

- **Fruit:** *In situ* grafting/ budding of fruits trees like mango and ber found to be more economical than using grafted plants. Custard apple, Jack and tamarind were other species suitable to wastelands.

  Mango, phylanthus and jambulina performed better in the non-arable land.

  Mango, pomegranate, sapota, guava, custard apple, jamun

- **Medicinal and aromatic plants:** *Catharanthus roseus, Cassia angustifolia, Solanum viarum, Dioscorea, Geranium, Pogostemon patchouli,* Jasmine.
- **Vegetables:** Tomato, chillies, okra, watermelon, drum stick, brinjal, bitter gourd.
- **Animal component:** Female and male cattle, female buffaloes, Sheep
- **Other enterprises:** Sericulture, piggery, goat rearing, rabbit rearing.

Contingent planning

- **Second fortnight of April**
  - Double cropping: Sesame or greengram
- **First fortnight of May**
  - Monocropping: Pigeonpea
  - Sequence cropping: Sesame, cowpea, greengram, blackgram, fodder maize, fodder pearlmillet, fodder sorghum.
- **Second fortnight of May**
  - Monocropping: Pigeonpea
  - Sequence cropping: Sesame, cowpea, greengram, blackgram, fodder maize, fodder pearlmillet, fodder sorghum.
- **First fortnight of June**
  - Monocropping: Long duration fingermillet, pigeonpea, maize, groundnut
  - Sequence cropping: Fodder maize, fodder sorghum, fodder pearlmillet, cowpea
- **Second fortnight of June**
  - Monocropping: Long duration fingermillet, pigeonpea, maize and groundnut
  - Sequence cropping: Sowing of chilli nursery
- **First fortnight of July**

  - Monocropping: Groundnut, long duration fingermillet
  - Sequence cropping: Sowing of chilli nursery
- **Second fortnight of July**
  - Monocropping: Groundnut, long/ medium duration fingermillet
  - Sequence cropping: Sowing of chilli nursery
- **First fortnight of August**
  - Monocropping: Cowpea, horsegram, short duration finger millet, transplanting chilli
  - Sequence cropping: Cowpea, horsegram, short duration finger millet, transplanting chilli.
  - Sowing of chilli nursery and short duration finger millet.
- **Second fortnight of August**
  - Monocropping: Short duration finger millet, transplanting of medium and long duration fingermillet. Transplanting chilli, cowpea, horsegram
  - Sequence cropping: Short duration fingermillet, transplanting of medium and long duration fingermillet, transplanting chilli, cowpea, horsegram, fodder crops (maize, pearlmillet, sorghum)
- **First fortnight of September**
  - Monocropping: Horsegram, transplanting of short duration fingermillet and chilli (with protective irrigation)
  - Sequence cropping: Horsegram, transplanting of short duration fingermillet and chilli (with protective irrigation)

Alternate/ contingency crop production practices for drought mitigation:

- Dry seeding in fingermillet, sorghum, pigeonpea and castor when monsoon is delayed. For crops with big seeds and less seed rate, like pigeonpea, pelletisation of seed is to be done before dry sowing.
- Maintain optimum plant population by thinning.
- Repeated inter cultivation coupled with weeding and weed mulching.
- Preventive measures against pests and diseases.
- Double split top dressing.
- Controlled grazing by animals to reduce excess vegetative growth and to minimize transpiration in fingermillet and horsegram

State	District	Region
Karnataka	Mysore Shimoga	Medium runoff and Medium yield gap

Agro-geographic setting	Mysore	Shimoga
Climate	Hot moist semi arid	Hot moist semi arid/ Hot moist sub humid to humid (transitional)
Physiography	Central Karnataka Plateau	Central and South Sahyadries
Soils	Sandy Alfisol – 100%	Sandy Alfisol – 100%
	Medium to deep red loamy soils	Medium to deep red loamy soils, Deep loamy to clayey red and lateritic soils
Annual rainfall (mm)	920	1045
Potential evapotranspiration (mm)	1535	1381
Length of growing period (LGP) / moisture availability period (days)	120-150	120-150 / 210-270

Soil and water conservation

Mysore

- ***In-situ* conservation practices:**
  - Opening a conservation furrow in between the paired rows in pigeonpea and maize for better moisture conservation.
  - Opening furrows on 0.2 to 0.4 slope
  - Graded ridge and furrows are made on 0.2 to 0.4 per cent grade for better conservation of moisture as well as safe disposal for cultivation of maize.
  - Conservation furrows at 3.3 m interval
  - Fall ploughing to a depth of 15-30 cm. for better infiltration of rainwater during onset of rains.
  - Summer tillage
  - Deep tillage to a depth of 25-30 cm. using mould board plough to reduce the weed incidence and increase soil moisture storage for sunflower and maize crops.
  - Cultivation across the slope with vetiver/ pennisetum grass as live barrier at 0.5 m vertical interval to check the velocity of runoff and better moisture conservation and availability for a longer period for fingermillet/groundnut/maize/sunflower crops.
  - More emphasis on *in situ* water conservation
  - Reducing soil crusting problem
  - Farm pond size of 250 m^3 plastered both sides and bottom with cement + sandy clay soils (1:8)
  - The existing bund itself could be modified to act as graded bund by internal land smoothening open end contour bunds (0.8 m^2) or graded bunds (0.36 m^2) on a slope of 0.2 to 0.4%. Waterways are viable with outlets.
  - Developing deeper soil (<45 cm) in to graded border strips of 10-12 m width on a gradient of 0.2 to 0.4

percent along the length

- Alleviation of crust is possible with the addition of FYM 10 t/ha, maize residue 5 t/ha and sand 25 t/ha

- **Long term conservation practices:**
  - Construction of contour bunds with a cross section of 0.54 m^2 to control and conserve runoff.
  - Construction of Graded bunds by providing 0.2 to 0.4 per cent grade with a cross section of 0.36 m^2 for safe disposal of excess runoff.
  - Graded boarder strips with a gradient of 0.1 to 0.5 per cent to fit into the local topography and hydrographic features.
  - Broad based bunds of 1.5 m^2 cross-sections on contour with 1 m vertical interval for better rainwater conservation.
  - Reduced contour bunds (0.36 m^2) in combination with vegetative live barriers for effective conservation of rainwater in low rainfall areas (< 600 mm)

Shimoga

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

Crop management

- **Varieties:** L–5, Indaf–8, MR–1, GPU–28, PR–102, HR–911, GPU–26, Indaf–5, Indaf–9

  Indaf – 8 for early in July

  GPU – 28, PR – 202 for early August sowing

  GPU – 26, Indaf – 9 for late sowing

- **Seed rate:** 10 kg/ha
- **Planting pattern**: 30 x7.5 cm / 22.5 cm x 10.0 cm. Spacing is same for drilling and transplanting
- **Nutrient management:** FYM 10 t/ha + 50 kg N + 50 kg P_2O_5 + 25 kg K_20 /ha. N in 2 equal splits, 1/3 at sowing or drilling and remaining 1/2 at tillering initiation; P and K basal placement
- **Some other important practices**
  - August sowing – short duration fingermillet, transplanted fingermillet 10-12 cm depth – ploughing
  - For establishing fingermillet in July – seed drilling is to be done
  - For late establishment – Transplanting the seedlings is essential

Suitable cropping systems

- Cowpea- fingermillet
- Greengram- fingermillet
- Blackgram - fingermillet
- Sorghum – transplanted fingermillet
- Pigeonpea paired rows-fingermillet (10:2)

- Fingermillet-field bean
- Fingermillet + pigeonpea (10:2) with conservation furrow between pigeonpea rows
- Fingermillet + soybean (1:1)
- Paired rows of pigeonpea followed by 8 rows of fingermillet with a furrow between pigeonpea. Planting of pigeonpea in May and fingermillet in July.

Farm implements/ tools

- **Bullock drawn seed-sum-fertilizer drill (fingermillet):** Bullock drawn manual operation for fingermillet seeding and fertilizer application (Hand metered) (Rs. 1500/- per unit)
- **Multifurrow opener:** Opening furrows for hand seeding of different crops (Rs. 1300/- per unit)
- **Bent Tyne hoe:** Intercultural operation for finger millet (Rs. 350/- per unit)
- **Duck foot hoe:** Intercultural operation for finger millet and groundnut for moisture conservation (Hand metered) (Rs. 350/- per unit)
- **Crust Breaker:** For breaking the crust to facilitate smooth emergence of the seedling in finger millet and groundnut (Rs. 500/- per unit)
- For opening furrows at 3.3 m interval simultaneously with sowing the seeds of finger millet, the newly designed seed drill with furrow opener is a convenient implement.
- Five coultered, 30 cm row spaced finger millet seed-cum-fertilizer drills should be used for sowing finger millet.

Alternate farming systems

Mysore

- **Fodder/ green biomass:** *Casuarina* and silver oak are better suited than other three species like eucalyptus, *azadirachta indica*, *Leucaena, Acacia* etc.

  Faidherbia albida is more suitable for planting on bunds (E-W direction) in micro-watershed.

  Stylosanthes hamata is most suitable. *Stylasanthes scabra* should be adopted for gravelly shallow soils with low rainfall.

  Acacia auriculiformis, Cassia siamea, Dalbergia sissoo, subabul and amla are more suitable and promising than other deep-rooted high water intensive tree species under high gradient non-arable lands with shallow soils and rock out crops. For better establishment, trench method of planting is better than pit method.

  Bamboo, jambulina, pongamia, *azadirachta indica*, *Albizzia lebbeck*, peepal, and ficus species can be planted in the catch pits and pockets of deep soil.

  Grasses like *Pennisetum pedicellatum or Cenchrus ciliaris* and legumes like *Microtelium axillaries* are suitable forage species.

  Leucaena leucocephala, Albizzia lebbeck, Dalbergia sissoo, Azadiracta indica, Pongamia, Cassia siamea

- **Fruit:** *In-situ* grafting/ budding of fruits trees like mango and ber found to be more economical than using grafted plants. Custured apple, Jack and tamarind were other species suitable to wastelands.

  Mango, Phylanthus and jambulina performed better in the non-arable land.

Mango, Pomegranate, Sapota, Guava, Custard apple, Jamun

- **Medicinal and aromatic plants:** *Catharanthus roseus, Cassia angustifolia, Solanum viarum, Dioscorea, Geranium, Pogostemon patchouli*, Jasmine
- **Vegetables:** Tomato, chillies, okra, watermelon, bitter gourd, Drumstick, Brinjal.
- **Animal component:** Female and male cattle, female buffaloes, Sheep
- **Other enterprises:** Sericulture, goat rearing, rabbit rearing, Piggery

Shimoga

- **Fodder/green biomass***: H.binata, Albizzia lebbeck, Leucaena leucocephala, Delbeusion sissoo, Azadiracta indica*.
- **Fruit:** Mango, sapota, pomegranate, fig and guava
- **Medicinal and aromatic plants:** *Vetiveria zyzanoides, Palma rosa, Cassia angustifolia, Catharanthus roseus*
- **Vegetables:** Tomato, chillies, brinjal, amaranthus, bitter gourd
- **Animal component:** Female and male cattle, female buffaloes, goat, sheep, poultry.

Contingent planning

Mysore

- **Second fortnight of April**
  - Double cropping: Sesame or greengram or sunflower or sorghum
- **First fortnight of May**
  - Monocropping: Pigeonpea
  - Sequence cropping: Sesame, cowpea, greengram, blackgram, fodder maize, fodder pearlmillet, fodder sorghum.
- **Second fortnight of May**
  - Monocropping: Pigeonpea
  - Sequence cropping: Sesame, cowpea, greengram, blackgram, fodder maize, fodder pearlmillet, fodder sorghum.
- **First fortnight of June**
  - Monocropping: Long duration fingermillet, pigeonpea, maize, groundnut
  - Sequence cropping: Fodder maize, fodder sorghum, fodder pearlmillet, cowpea
- **Second fortnight of June**
  - Monocropping: Long duration fingermillet, pigeonpea, maize and groundnut
  - Sequence cropping: Sowing of chilli nursery
- **First fortnight of July**
  - Monocropping: Groundnut, long duration fingermillet
  - Sequence cropping: Sowing of chilli nursery

- **Second fortnight of July**
  - Monocropping: Groundnut, long/ medium duration fingermillet
  - Sequence cropping: Sowing of chilli nursery
- **First fortnight of August**
  - Monocropping: Cowpea, horsegram, short duration finger millet, transplanting chilli
  - Sequence cropping: Cowpea, horsegram, short duration finger millet, transplanting chilli.
  - Sowing of chilli nursery and short duration finger millet.
- **Second fortnight of August**
  - Monocropping: Short duration finger millet, transplanting of medium and long duration fingermillet. transplanting chilli, cowpea, horsegram
  - Sequence cropping: Short duration fingermillet, transplanting of medium and long duration fingermillet, transplanting chilli, cowpea, horsegram, fodder crops (maize, pearlmillet, sorghum)
- **First fortnight of September**
  - Monocropping: Horsegram, tansplanting of short duration finger millet and chilli (with protective irrigation)
  - Sequence cropping: Horsegram, transplanting of short duration finger millet and chilli (with protective irrigation)

Alternate/ contingency crop production practices for drought mitigation

Mysore

- Dry sowing in fingermillet, sorghum, maize, pigeonpea, groundnut and castor when monsoon is delayed. For crops with big seeds and less seed rate, like pigeonpea, pelletisation of seed is to be done before dry sowing.
- Maintain optimum plant population by thinning.
- Repeated inter-cultivation coupled with weeding and weed mulching.
- Preventive measures against pests and diseases.
- Double split top dressing.
- Controlled grazing by animals to reduce excess vegetative growth to prevent transpiration in fingermillet and horsegram

MAHARASHTRA

In Maharashtra there is one district Kolhapur under medium runoff and medium yield gap region and two districts viz. Nasik and Pune under low runoff and medium yield gap region. The trends in area, production and productivity of fingermillet in Maharashtra (1980 - 2005) are shown in Fig. 24.

State	District	Region
Maharashtra	Kolhapur	Medium runoff and Medium yield gap

Agro-geographic setting	Kolhapur
Climate	Hot dry sub humid/ Hot moist sub humid to humid (transitional)
Physiography	North Sahyadries
Soils	Vertisols – 50%; Vertic soils – 50%
	Shallow and medium loamy and clayey black soils, deep clayey black soils, Deep loamy to clayey red and lateritic soils
Annual rainfall (mm)	1137
Potential evapotranspiration (mm)	1636
Length of growing period (LGP) / moisture availability period (days)	180 - 210

Soil and water conservation

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

Farm implements/ tools

- Bullock drawn tow bowl ferti-seed-drill
- Bullock-drawn two row seed-cum fertilizer drill
- Bullock-drawn Shivaji multi-purpose farming machine (3 rows)
- Two bowl seed and fertilizer drill

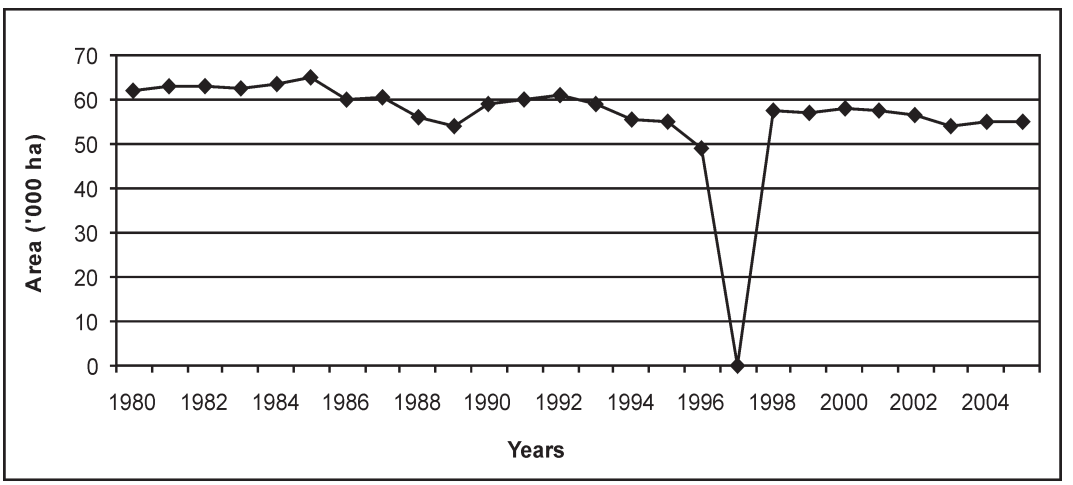
Alternate farming systems

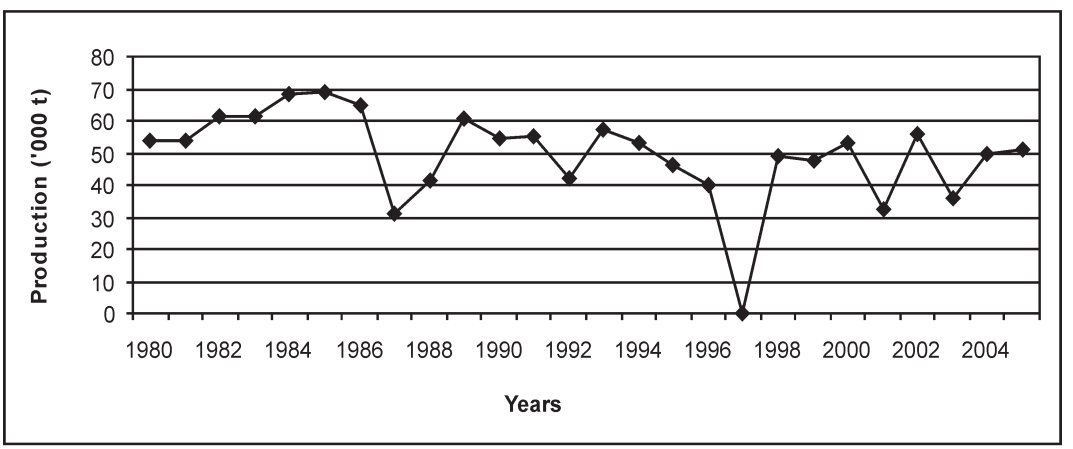
- **Fodder/green biomass:** Stylo in initial 1-2 years of main crop cultivation of Marvel-8 grass on bunds for protection of bunds and for fodder.

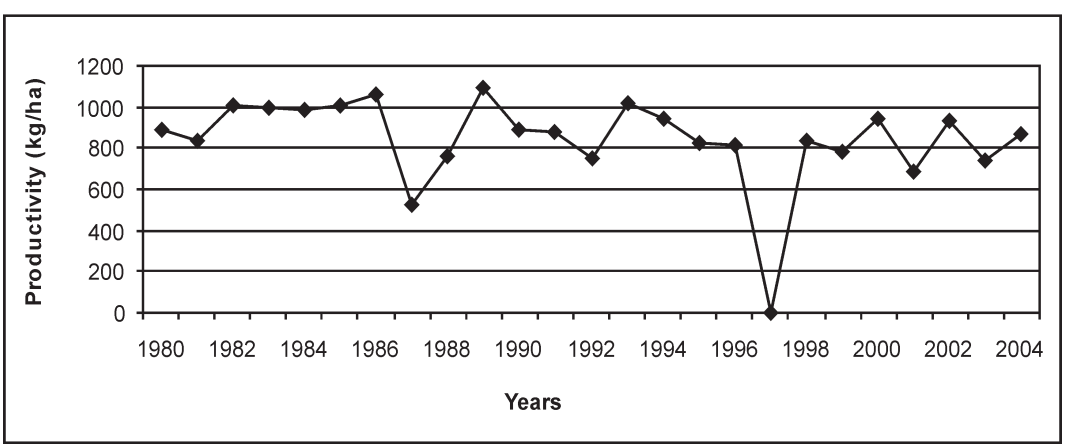
  Contour live bunds of Marvel-8 of Leucaena.

  Delbergia sissoo, M.azadirachta, Albizzia lebbeck, Anogeissus latifolia, Sesbania, A. excelsa, Cassia siamea

Fig. 24. Trends in Area, Production and Productivity of Fingermillet in Maharashtra (1980-2005)







- **Fruit:** Ber, amla with intercropping of *Kharif* (spreading) crops.

  Pomegranate, mango, sapota, custard apple, fig, jamun
- **Medicinal and aromatic plants:** *Catharanthus roseus, Palma rosa, Vetiveria zyzanoides, Rose, Geranium*
- **Vegetables:** Onion, tomato, okra, cowpea, cluster bean, drumstick
- **Animal component:** Female and male cattle, female buffaloes, goat, sheep and poultry

State	District	Region
Maharashtra	Nasik Pune	Low runoff and Medium yield gap

Agro-geographic setting	Nasik	Pune
Climate	Hot semi arid	Hot semi arid/ Hot dry sub humid/ Hot humid
Physiography	Western Maharashtra Plateau	North Sahayadris
Soils	Vertic soils – 85%; Vertisols – 15%	Vertic soils – 65%; Vertisols – 35%
	Shallow and Medium loamy, medium and deep clayey black soils	Shallow and Medium loamy, medium and deep clayey black soils, Shallow and medium loamy and clayey black soils, deep clayey black soils, Medium to deep loamy to clayey mixed red and black soils
Annual rainfall (mm)	591	715
Potential evapotranspiration (mm)	1659	1476
Length of growing period (LGP) / moisture availability period (days)	120-150	90-120 / 150-180 / 210-240

Soil and water conservation

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

Farm implements/ tools

- Bullock drawn tow bowl ferti-seed-drill
- Bullock-drawn two row seed-cum fertilizer drill
- Bullock-drawn Shivaji multi-purpose farming machine (3 rows)
- Two bowl seed cum fertilizer drill

Alternate farming systems

- **Fodder/green biomass:** Stylo in initial 1-2 years of main crop

  Cultivation of Marvel-8 grass on bunds for protection of bunds and for fodder.

  Contour live bunds of Marvel - 8 of *Leucaena.*

  Delbergia sissoo, M.azadirachta, Albizzia lebbeck, Anogeissus latifolia, Sesbania, A. excelsa, Cassia siamea
- **Fruit:** Ber, Amla with intercropping of *Kharif* (spreading) crops.

  Pome granate, mango, sapota, custard apple, fig, jamun
- **Medicinal and aromatic plants:** *Catharanthus roseus, Palma rosa, Vetiveria zyzanoides, Rose, Geranium.*
- **Vegetables:** Onion, tomato, okra, cowpea, cluster bean, drumstick
- **Animal Component:** Female and male cattle, female buffaloes, goat, sheep and poultry.

ORISSA

In Orissa there are three districts viz Ganjam, Kalhandi and Koraput under medium runoff and medium yield gap region. The trends in area, production and productivity of fingermillet in Orissa (1980 - 2005) are shown in Fig. 25.

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

Agro-geographic setting	Ganjam	Kalahandi	Koraput
Climate	Hot (moist/ dry) sub humid/ Hot dry sub humid	Hot moist sub humid	Hot moist sub humid
Physiography	Eastern ghats	Eastern ghats	Eastern ghats
Soils	Orthids – 40%; Sandy Alfisol – 60%	Ustalf/ Ustolls – 70%; Loamy Alfisols – 30%	Loamy Alfisol – 80%; Sandy Alfisol – 20%
	Medium to deep loamy red and lateritic, deep loamy to clayey coastal and Deltaic Alluvium derived soils, Deep loamy to clayey coastal and deltaic alluvium - derived soils	Deep laomy red and lateritic soils	Deep laomy red and lateritic soils
Annual rainfall (mm)	1311	1511	1671
Potential evapotranspiration (mm)	1662	1524	1630
Length of growing period (LGP)/ moisture availability period (days)	180-210	180-210	180-120

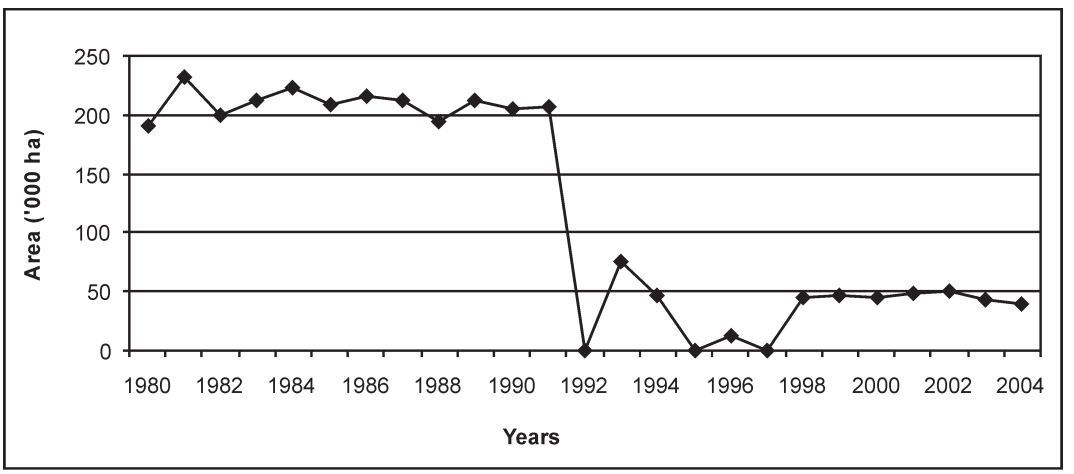
Soil and water conservation

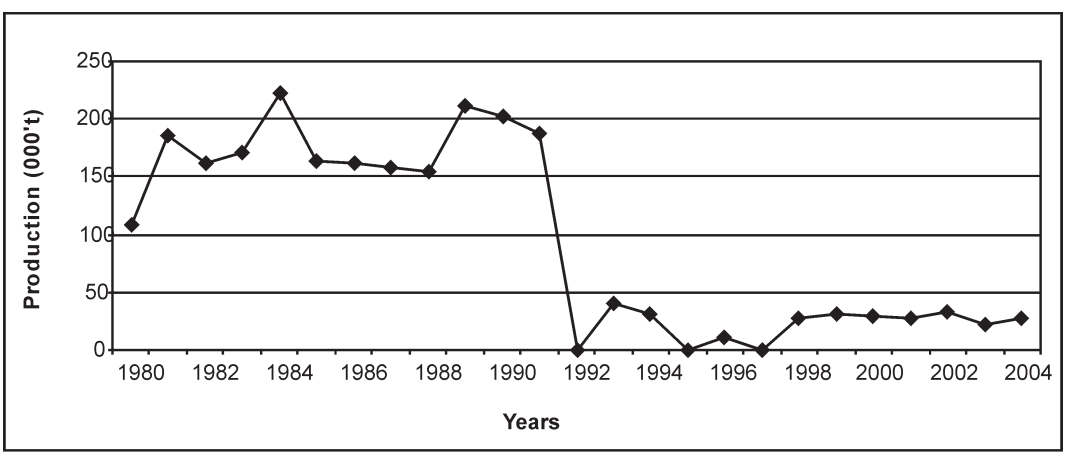
- Bench terracing
- Compartmental bunding
- Graded border strips
- Sowing across the slope and ridging later
- *Insitu* conservation of soil moisture

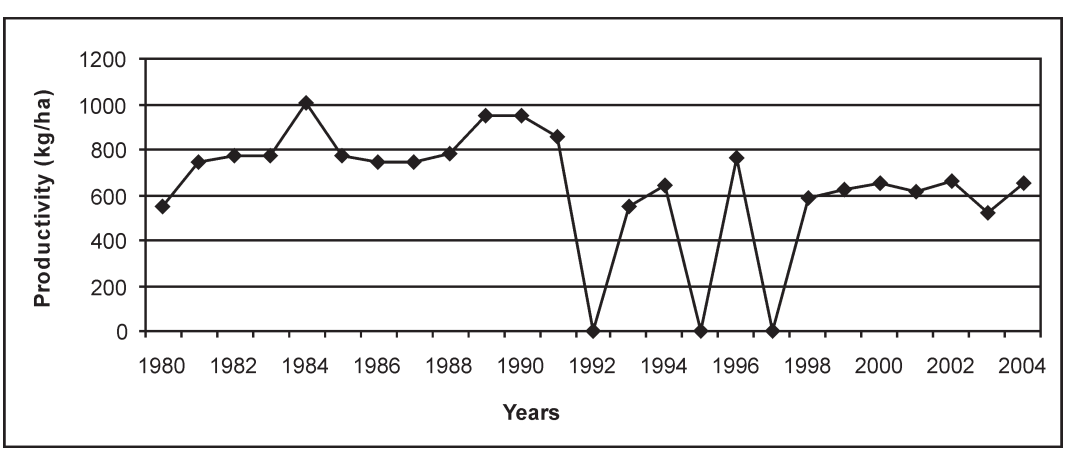
Crop management

- **Varieties:** Dibyasinha, Nilachala, Bhairabi, OEB - 10; BM 9 - 1; GPU - 45; OUAT - 2; AKP - 2.
- **Seed rate:** Direct sown : 10 kg /ha
  - Transplanted: 6 kg/ha
- **Planting pattern:** Direct sown : 22.5 x 10 cm rows
  - Transplanted: 22.5 x 10 cm

Fig. 25. Trends in Area, Production and Productivity of Fingermillet in Orissa (1980-2005)







- **Nutrient management:** 40 kg N + 20 kg P_2O_5 + 20 kg K_2O/ha. Apply all P and K and 50 % N as basal and 50% N at 21 days after sowing

Suitable cropping systems

- Pigeonpea (T-21, R-60) + fingermillet (Dibyasingha)
- Four rows of short duration, short statured fingermillet in 20 cm apart rows are intercropped in 100 cm inter space between paired rows of pigeonpea with set specification 30-100-30 cm.
- Finger millet + Pigeonpea – 8:2 proportion.

Farm implements/ tools

- Hand Hoe

Alternate farming system

- **Non – arable wastelands**
  - Tree farming (Sal*, Teak*)
  - Silvi-pastoral *(Shisham/Subabul/Gambar* + Stylo/Cenchrus/mixure)
- **Arable lands**
  - **Agri-horticulture:** Fruit crops (mango/ citrus/ sapota/ pomogranate/ custard apple /aonla/ 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* + turmeric/ ginger

  Subabul (4 m interval) + groundnut/ sesame/ cowpea (grain)
- **Fodder/green biomass:** *P.pinnata, Albizzia sps, Cassia siamea, Grevellea robusta, D. sissoo, Azadirachta indica.*
- **Fruit:** Mango, jackfruit, guava, lime
- **Medicinal and aromatic plants:** *Vetiveria zyzanoides, Cymbopogan flexuosus, Palmarosa, Solanum viarum, Cinnamon, Citronella, java*
- **Vegetables:** Bottle gourd, brinjal, ridge gourd, watermelon, long melon, bitter gourd, tomato
- **Animal component:** Female and male cattle, goat

Contingent planning

- **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 and Parijat
- Early medium (115 days to 120 days): Sarathi and Bhoi
- Medium duration (125 to 145 days): Lalat, IR-64, Konark, Gajapati, Surendra, Jajati, Swarna, MTU-1001 and Padmini
- Late duration : Utkalaprava, Gayatri, Savitri,Prachi, Ramachani , Mahanadi and Indrabati

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

Aberrant weather

Upland

• Early season drought/Delay in onset of monsoon

When upland rice is completely damaged, the crop may be cut to the bottom for supplying straw to the cattle. Non-paddy crops viz. fingermillet (Subhra, Bhairabi, Dibyasingha and Godavari), greengram (K 851, PDM-11 and PDM-54), blackgram (T-9, Sarala and Pant U-30), cowpea (SEB-2, SGL-1, Arka Kamal), horsegram (Urmi), ricebean (RBL - 6), sesame (Usha, Uma) and castor (Aruna, DCS-9), niger (IGP-76 and Deomali) or sunflower (Morden) should be taken. Drought tolerant varieties of crop(s)/ cropping system(s) should be taken up. The crop variety should be selected based on available effective growing season.

• Mid-season drought

- Weeding and hoeing should be done in all the crops except groundnut in flowering stage. Weeds in groundnut should be cut or uprooted not to interfere in pegging and pod formation. Hoeing creates soil mulch and decreases moisture loss from the soil. Uprooted weeds should be used as mulch between crop rows.

- Foliar spraying of 2% urea in upland rice and fingermillet gives good results. For this, 200 g of urea is mixed with 10 litre of water and sprayed on the foliage of the crop. Plant protection chemicals may be mixed with urea solution to minimize the cost of spraying. In a single spray 10 kg/ha of urea is applied through 500 litre solution.
- Excess plants in the crop row should be thinned to reduce moisture loss from the soil.
- Use of tender twigs of *Leucaena, Glyricidia sepium, Cassia siamea* and *Mimosa invisa* and plants of sunhemp as mulch-cum-manure reduces evaporation loss from the soil.
- Spraying of planofix 10 ppm at 45 days after sowing and 20 ppm at flowering in cotton to prevent fruit drop.

Late season drought: Harvested rainwater should be recycled as life saving irrigation.

Medium and low land

Direct sown rice:

- Re-sowing of rice is needed if plant population is less than 50%. Line sowing of pre-germinated seeds of rice (125 days duration) should be done. Nursery for comparatively shorter duration rice varieties may be done.
- If plant population is more than 50% and *beushening* 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, tractor drawn power tiller or rotovator for better puddling does. 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.

Prioritized management options are:

State	District	Management options	Average Yield (kg/ha)	Expected Yield with adoption (kg/ha)
Andhra Pradesh	Mahbubnagar, Vishakhapatnam	High yield cultivars, pest and disease management packages, improved management practices along with *in situ* water management activities.	876	1000 to 1050
Karnataka	Mandya	High yield cultivars, pest and disease management packages, improved management practices along with *in situ* water management activities.	876	1000 to 1050
	Kolar	Improved management practices along with *in situ* water management activities.	1629	1800 to 1900
	Mysore, Shimoga	Improved management practices along with *in situ* water management activities, pest and disease management packages, water harvesting for supplemental irrigation and to raise a successful second crop.	1265	1450 to 1550
Maharastra	Nasik, Pune	High yield cultivars, pest and disease management packages, improved management practices along with *in situ* water management activities.	876	1000 to 1050
	Kolhapur	Improved management practices along with *in situ* water management activities, pest and disease management packages, water harvesting for supplemental irrigation and to raise a successful second crop.	1265	1450 to 1550
Orissa	Ganjam, Kalahandi	Cultivation could be limited to uplands only high yield cultivars, improved management packages, water harvesting for efficient utilisation of available water	774	900 to 950
	Koraput	Cultivation could be limited to uplands only high yield cultivars, improved management packages, water harvesting for efficient utilisation of available water	977	1150 to 1200

POPULAR AND BOTANICAL NAMES OF SOME RAINFED 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
Paddy (Rice)	*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 coracana* (L.) Gaertn
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

GENERIC AND BRAND NAMES OF SOME PESTICIDES

Heribicides/ Weedicides

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

ANILOPHOS 30% EC: Aerozin (Agr. Evo), Sumo (Dupont), Glyphotox (AIMCO), Ricil (De'Nocil), Anilostar (Shaw 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 8 G, 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)

Insecticides

ALDICARB: Temic 10 G (Rhone Poulenc)

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

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

CARBOSULPHAN 25% DS: Marshal (Rallis)

CHLORPYRIPHOS 20 EC, 10 G, 1.5 DP: Coroban (Coromandal Indag), Blaze (Indofil), Dursban, Ruban (De'Nocil), Sulban (Sulphur Mill), Specphos 20 (Southern Pesticides), Hyban (Hyderabad Chemicals), Radar (Searle India), Nuklor 20EC (Dupont), Corocin (IOCL), Scout (AIMCO), Dhanwan 20 (Dhanuka), Durmet 20EC (Cyanamid Agro), Classic (Lupin), Starban (Shaw Wallace), Doomer (Bhaskar Agro), Hilban (Hindustan 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 10 EC: 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 20 EC, 10% Gr: Basudin (Novartis), Tik-20 (Rallis)

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

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

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

ENDOSULFAN 35 EC & 4% D, 2% D: Thiodan (Agro Evo), Endocel (Excel), Endosul (Sulphur Mills), ENDOSTAR (Shaw 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 20 EC 0.4% DUST: Fenval (Searle Inida), Bilfen (Bayer), Starfen (Shaw Wallance), Fen-Fen (Parry Chemicals), Topfen (Thakar Chemicals), Tagfen (Tropical Agro), Trump Card (Dhanuka), Hilfen (Hindustan Insecticides), Fencron (Novartis), Sumitox (AIMCO), Fenkill (United Phosphorous), Lufen (Lupin), Starfen (Shaw Wallance), Agrofen (Gujarat Agro), Bhaskarfen (Bhaskar Agro), Newfen (Gharda), Fenkem (New Chemi), Anchor (ICI-Zeneca), Fenny (NFCL), Viper (SPEC), Milfen (Montari), Tatafen (Rallis), Fennock 20 (De'Nocil), Bhasma (Wockhardt)

FIPRONIL 0.3% Gr, 5% SC: Regent (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 (PesticidesIndia), Agromonark (Gujarat Agro), Moncar (Bhaskar Agro), Azodrin (Cyanamid Inida), Hilcron (HindustanInsecticides), Macrophos (Tropical Agro), Croton (Searle India), Balwan (Rallis), Monophos (Parry Chemicals),Monocron (NFCL), Corophos (Coromandel Indag), Bilphos (Bayer), Monosect (Arg Evo)

METHYL-PARATHION 50 EC: Metacid (Bayer), Parataf (Thakar Chemicals), Dhanumar (Dhanuka), Milion (Montari), Paratox (AIMCO), Luthion (Lupin), Devithion (Devidayal), Tagpar (Tropical Agro System), Paramar M. (Parry Chemicals), Agro-Para (Gujarat Agro), Parataf (Rallis)

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

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

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

PHOSALONE 35% EC & 4% Dust: Zolone (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 25 EC: Ekalux AF (Novartis), Quinaltaf (Rallis), Flash (Indofil), Quinal (Sulphur Mills), Suquin (Sudershan Chemicals), Quinguard (Gharda), Starlux (Shaw Wallace), Knock (Southern Pesticides), Hyquin (Hyderabad Chemicals), Ekatop (Thakar Chemicals), Smash (Searle India), Chemlux (New Chemi), Shakti (E.I.D. Parry), Dhanulux (Dhanuka), Quinatox (AIMCO), Kinalux (United Phosphorous), Vazra (Lupin), Agroquin (Gujarat Agro), Basquin (Bhaskar Chemicals), Hilquin (Hindustan Insecticides), Tagquin (Tropical Agro), Quick (NFCL), Volquin (Voltas), Bayrusil (Bayer), Krush (Wockhardt)

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

THIODICARB 75% WP: Larvin (Rhoune-Poulnec)

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)