

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

Districtwise Promising Technologies for Rainfed Rice based Production System in India



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

Santoshnagar, Hyderabad 500 059

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About this compendium

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

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

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Edited by
KPR Vittal
PK Sinha
G Ravindra Chary
GR Maruthi Sankar
YS Ramakrishna
T Srijaya
JS Samra
Gurbachan Singh



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Contributors

All India Coordinated Research Project for Dryland Agriculture (AICRPDA), Hyderabad, AP

G Ravindra Chary
GR Maruthi Sankar
KPR Vittal

Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, AP

JVNS Prasad
KV Rao
M Srinivasa Rao
US Victor
YG Prasad
YS Ramakrishna

Central Rainfed Upland Rice Research Station, CRRI, Hazaribagh - 625 301, Jharkhand

PK Sinha
VD Shukla
RK Singh
M Variar
CV Singh
D Maiti
NP Mandal

Indian Council of Agricultural Research (ICAR), New Delhi

JS Samra
Gurbachan Singh

Secretarial assistance by

G Varalakshmi

Cover

Greening the grey areas

GIS Support by

D Sai Kiran
M Arunachalam

AICRPDA Centres

A Rafey, Ranchi
AL Pharande, Solapur
B Behera, Phulbani
Bhagawan Singh, Faizabad
MA Shankar, Bangalore
RA Sharma, Indore
SC Sharma, Rewa
SM Patel, Akola
SR Singh, Varanasi

Agro-Industries

Fertilizers
Implements
Pesticides
Seeds

State Department(s) of Agriculture

Bihar
Chattisgarh
Jharkhand
Karnataka
Madhya Pradesh
Maharashtra
Orissa
Uttar Pradesh

Technical assistance by

A Girija, RVVSGK Raju, L Sree Ramulu

Designed by

I Ram Mohan

Supported by

T Srijaya, M Uday Bhanu, RD Dinesh Kumar,
CH Satish Babu, Vibha Srivastava

Other assistance

N Manikya Rao, V Amarender, Sree Ramulu, Bhanu Prakash

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RAINFED RICE BASED PRODUCTION SYSTEM

In India, rice area stretches from 79° to 90° E longitude and 16° to 28° N latitude. It is cultivated as a purely rainfed upland crop in West Bengal, Bihar, Uttar Pradesh, etc., where the monsoon is precarious and its distribution is often erratic. Rainfed rice in India constitutes up to 55% of the total rice area. Of this, 15% area is upland and 33% low land. The remaining 7% is flood prone. The uplands, lowlands, flood prone areas and irrigated areas contribute 5, 30, 4 and 61% to the total rice production. Thus low lands become the most important rainfed rice ecosystem in the productivity context. One ton per ha of rice productivity under rainfed conditions has crossed only in Maharashtra and Uttar Pradesh. The States like Bihar, Orissa and Madhya Pradesh still continues to be below one ton barrier. However, the productivity in irrigated areas of these states has exceeded the one ton barrier.

Upland rice area is declining due to drought, weed problems, instability in production, declining soil fertility and productivity, and development of irrigation facilities. As per recent estimate the upland rice area is around 5.50 M ha in India and there has been shift in area from minor millets to upland rice due to availability of improved varieties. Upland rice is mainly grown in acid upland soils in Uttar Pradesh and north-eastern India, red lateritic soils of western Orissa alluvial plains of coastal Orissa, and eastern Uttar Pradesh. Phosphorus is one of the major limiting nutrients in acid uplands and lateritic soils. Most of the upland rice areas are left fallow after harvest but there are other production systems like Jhum cultivation in north-eastern region, horsegram (Kulthi) after upland rice in Orissa, and intercropping or mixed cropping with pigeonpea that are more sustainable systems for improving soil quality of upland rice (Singh, 2002).

State	Rice (kg/ha)	
	Irrigated	Rainfed
Bihar	1251 (143)	821 (62)
Orissa	1232 (205)	706 (137)
Madhya Pradesh	1510 (125)	765 (403)
Maharashtra	1421 (340)	1367 (147)
Uttar Pradesh	1581	1163

Figures in Parentheses are SD: Data source: Fertilizer Statistics (1985 – 1996)

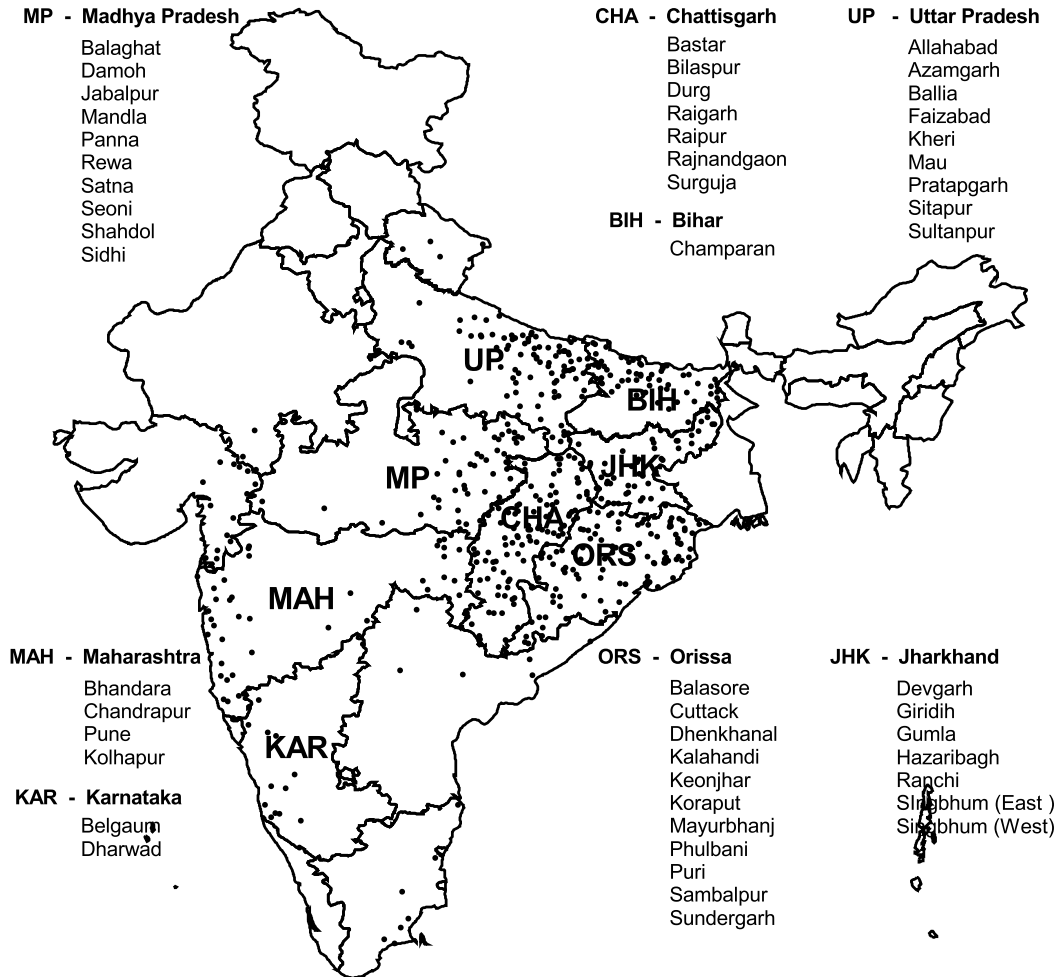
Rainfed rice is grown in 346 districts of in sixteen states viz. Bihar, Orissa, Chattisgarh, Madhya Pradesh, Maharashtra, Uttar Pradesh, West Bengal, Jharkhand, Karnataka, Andhra Pradesh, Tamil Nadu, Gujarat, Rajasthan, Punjab and Uttaranchal. But the extent varies significantly. The climate ranges from arid, semi-arid to humid in these states. The districts covering 85% of the rainfed cropped area were recognized as a rainfed rice region this region covers an area of 13.22 mha in 55 districts in the 16 states. Some further details are given in these table:

Selection criteria	No. of Districts	Area under rainfed rice ('000ha)	Gross cropped area ('000ha)	Yield (kg/ha)
Sixteen states	346	32923	15078	1682
Agro Eco Region 3-13	261	26892	11156	1696
85% Rainfed rice area	55	13221	9449	1204

The dominant rainfed rice growing districts are spread over Orissa, Bihar, Chattisgarh, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra and Uttar Pradesh. The spatial distribution and districts are shown.

Statistically significant trends in area and yield growth rates for different districts are given in the following table.

RAINFED RICE REGION Priority Districts



• 1 Dot = 25,000 ha

Area	Yield	State	Districts
Increasing	Increasing	Chattisgarh Uttar Pradesh Orissa	Durg, Raipur, Bilaspur, Raigarh, Surguja Azamgarh, Faizabad, Sultanpur, Pratapgarh Bolangir, Koraput, Mayurbhanj
Stagnant	Stagnant	Madhya Pradesh Uttar Pradesh Orissa	Panna Allahabad, Ballia, Sitapur, Kheri Balasore, Cuttack, Ganjam
Stagnant	Increasing	Chattisgarh Madhya Pradesh Maharashtra Orissa	Bastar Jabalpur, Balaghat, Mandla, Damoh, Shahdol Kolhapur, Chandrapur Kalahandi, Phulbani, Puri, Sundargarh
Stagnant	Stagnant	Madhya Pradesh Karnataka Maharashtra Orissa	Seoni, Rewa, Sidhi, Satna Dharwad, Belgaum Bhandara Dhenkanal, Keonjhar, Sambalpur
Decreasing	Decreasing	Maharashtra	Pune

By analysis of crops and animals in the identified districts, following clusters are identified.

Crops	Animals	Districts
Rice	Cattle (Female/ Male) Goat	Durg, Bastar, Raipur, Bilaspur, Raigarh, Surguja, Balaghat, Sahdol, Bhandara, Rajnandgaon, Gadchiroli, Hazaribagh, Ranchi, Giridih, Gumla, Singhbhum (east), Singhbhum (west)
Rice Wheat Sorghum Chickpea	Buffalo (Female) Cattle (Female) Cattle (Male) Goat	Jabalpur, Seoni, Damoh, Panna, Rewa, Sidhi, Satna, Dharwad, Belgaum, Pune, Chandrapur
Rice Greengram Fruits Vegetables	Cattle (Female) Cattle (Male)	Mandla, Bolangir, Cuttack, Dhenkna, Ganjam, Kalahandi, Koraput, Phulbani, Puri, Sambalpur
Rice Groundnut Sugarcane	Buffalo (female and male), Cattle (female and male) Sheep Goat	Kolhapur
Rice Maize	Buffalo (Female) Cattle (Female and Male) Goat	Panchmahals, Ballia, Sitapur, Champaran (East).
Rice Vegetables	Buffalo (Female) Cattle (Female and Male) Sheep Goat	Allahabad, Faizabad, Sultanpur, Pratapgarh, Dumka
Rice	Buffalo (Female) Cattle (Female and Male) Goat	Azamgarh, Sidharth Nagar
Rice Fruits Vegetables	Cattle (Female and Male) Sheep Goat	Balasore, Keonjhar, Mayurbanj, Sundargarh, Deoghar

Rainfed rice growing scenarios

Rice cultivation is conditioned by temperature parameters at the different phases of growth. The critical mean temperature for flowering and fertilization ranges from 16 to 20°C, where as during ripening the range is from 18 to 32°C. Temperatures beyond 35°C affect not only pollen – shedding, but also grain filling. For vigorous vegetative growth, moderately high temperatures are required, whereas, for panicle initiation, slightly lower temperature (20 to 22°C) would be ideal. High temperatures and high light intensity adversely affect grain filling. Rice can be cultivated best in soil having pH 5 to 8.5. This crop is known to be fairly tolerant to soil salinity crop, can grow normally in soil upto 6 mmhos/cm conductivity. Soils having exchangeable sodium percentage greater than 15 may adversely affect the growth.

Chattisgarh: In Chattisgarh, 4.67 m. ha. area is being cultivated during *kharif* season, of which 3.55 m ha. is occupied by rice crop. Depending upon the rainfall 20-25 per cent area of the state goes under partial or full irrigation systems. The state has been divided in to three agro-climatic zones, i.e. Chattisgarh plain, Blaster plateau and Northern hill region. The characteristics of the upland under these situations have great variability with respect to soils type and productivity of rice. In Baster plateau and Northern hills region very high undulating and rolling topography with shallow soil depth and poor moisture holding capacity and fertility status soil, exists. Even under medium bunded lands the moisture holding capacity and fertility status in poor. In the state about 5 lakh hectares area upland rice is being grown on upland (un-bunded or with small bunds), which is affected by drought at one stage or the other.

The major constraints identified are soil (topography, texture, structure, depth, pH and poor moisture retention capacity) climate (erratic rainfall distribution pattern, early withdraw of monsoon at later crop growth stages) and management (poor adaptability of short duration and drought resistant varieties, weed management, high weed infestation, low fertilizer use, low plant population, methods of seeding and bird damage). All these constraints severely affects the yield of rice and productivity seldom exceeds 0.9 t/ha (Tripathi, 2002)

The northern hill is on of the important tribal dominating region of Chattisgarh for rice production. The topography of the region is characterized as hilly and undulating having steep slope of varying degrees (1-5%). The soil classes are locally known as Dand (upland unbunded), Goda chawar (Upland bunded), Gader chawar (Low land) and Bahara (Extreme lowland). The climate of the region is sub-humid, mild in summer and moderate in winter. The average annual rainfall is 1450 mm varying from 1448.3 to 1726.6 mm. Monsoon generally starts from second week of June and withdraws during September.

Six farming situations have been identified on the basis of prevalent agricultural practices, topography and soil type in the region which are Hilly (10%), Upland Unbunded (30%), Upland Bunded (25%), Low Land Bunded (15%), Low Land Large (10%).

The area under upland soils situation is 30% of total cultivated area of the region. The upland soils are light, unfertile eroded with poor retention of soil moisture due to which rainfed cultivation under irregular monsoon distribution becomes a problems for rice production. The major constraints is illiterate tribal population, poverty, small holdings, credit facilities, lack of source and supply of quality seed, fertilizers and other inputs, transportation facilities, marketing farming traditions, insect and disease problems. Over all, socioeconomic status of the farmers of the region is poor which influence adoption of improved production technology, resulting in lower production of the region than the other rice growing ecologies/ regions (Sangar, 2002)

Jharkhand: The plateau region situated between 22.0° to 25.5° North and 83.5° to 88.0° East was separated from the Bihar on 15 November, 2000 and named as Jharkhand state. The total geographical area of the Jharkhand state is 79723 km² (7972300 ha) out of which, only 2.039 m ha are grossed cropped area. Majority of the cultivated land is mono cropped and seeded with rice and other crops during wet season. The total under rice cultivation (at maximum coverage) is 1.525 m ha. Out of these rice land, only 3905 ha is under irrigation and the summer rice is grown in these lands. The total production of rice in the state is 2.204 million tones. The majority of population is dependent on agriculture and the grains produced from these lands are sufficient only for a period of less than six months. At the same time, 60% of the population in state is below poverty line.

In Jharkhand, The rainfall is received during the Southwest monsoon period of June-October. The annual rainfall varies from 1000-1600 mm. From rainfed rice cultivation point of view, the rainfall is categorized

from medium (1400-1600 mm), moderately medium (1200-1400 mm) and low (1000-1200 mm). In these categories, either intermittent or terminal drought limits the rice productivity. The rainfall quantum has a relationship with the annual number of rainy days. A majority of district of the state receives rainfall in 50 to 80 days. With intermittent dry spell during the rainy season, the length of rainy season is always greater than the number of rainy days. The crop growing season is always greater than the rainy season and is dependent not only on rainy season but also on the water availability periods and the soil characteristics like water holding capacity. Levels of drought, risk and low yields characterized the rice production system of Jharkhand. In spite of the importance of rice in the state's economy, rice yield growth remains very low in comparison with national growth. The major features of rice production systems have changed very little over the last 15 years. In total, the percentage change of rice area was negative for rainy season and winter season rice but, the percentage change of rice production was positive for all season rice. The rainy and winter season rice dominated the rice production as these two contribute to more than 99% of total rice production in Jharkhand. In farmers perception, the lack of irrigation facilities, scattered and small land holdings, quality seeds and technology interventions are major constraints of low rice productivity in the state (Singh, *etal*, 2002)

Eastern Ghat High Land Zone of Orissa: Eastern Ghat High Land Zone (EGHILZ) of Orissa comprises of 9.95 lakh hectare out of which 41.83% is the net cultivable area. The climate is warm and humid with an average annual rainfall of 1347 mm and the temperature ranging between 7.5^o C to 34.1^o C. The farming community is resource poor but fond of rice which is treated as their status symbol, however they also cultivate finger millets, ricebean, and niger. Rice is cultivated as a rainfed crop, occupies 26.44% of the total cropped area and is grown in upland, medium land and low land. The upland is locally called as Dangara land which is of three types namely Dangara I, II and III occupying 58.13% of the cultivable land. The upland is mostly un-bunded and undulating with low water holding capacity. The soil of the upland is red, sandy to sandy loam, acidic in nature, having low organic matter and low NPK content.

Cultivation of the upland rice is a risky proposition due to erratic rainfall pattern, weed menace and blast infestation. The tribal farmers are taking up rice in the risk prone rainfed upland under poor crop management leading to low production. The local rice cultivars grown in the zone are namely Aleswara, Aatiaa, Baragi kuji, Bhatkunda, Chigididhan, Chipiti Dasra kate, Dasara mathia, Dangara Alasi, Dangara Dhana, Dangara Ganthia, Dangara Kuji, Godidhan, Godikaberi, Kalagumuda Kaldadi, Kandulakathi, Kaubadi Khatlamengo, Laludhan (Scented), Mahulakachi. Makaradhan, Meera, Mitimita, Pandukagora, Paradhan, Sataka etc. The farmers of this zone also grow the high yielding released varieties recommended for upland situation. These varieties are namely, Annada, Badami, Vanaprabha, Culture-1, Ganteswari, Heera, Kalinga III, Kalyanill, Khandagiri, Parijat, Pathara, Rudra, Sankara, Subhardra, Udayagiri, Vandana, etc (Sabyasachi Rath, 2002)

Rainfed rice ecologies

Upland rice is cultivated as direct seeded in aerobic, well drained soils with no or little surface water accumulation, and ground water table is below 50 to 100 cm during the cropping season. It can be rainfed or irrigated (with sprinkler irrigation, as in Brazil) to supplement as and when needed during the rainless period of crop growth. IRRI (1984) classified upland rice in 4 types; *Favourable Uplands with Long growing season; Favourable Uplands with Short growing season; Unfavourable Uplands with Long growing season; and Unfavourable Uplands with Short growing season.* In India, the later three categories are common, and drought prone SF are widespread in eastern and central India. Upland rice is grown in flat lands in coastal Orissa, Assam and eastern Uttar Pradesh; gently rolling lands (up to 8% slope) in Chattisgarh and Madhya Pradesh, and sloppy lands (> 30% slope) in Jharkhand, western Orissa, Meghalaya and Uttaranchal hills. Around 70% of upland rice area are drought prone, Orissa, Himachal Pradesh, Uttaranchal hills. Around 70% of upland rice area are drought prone, and other 30% favourable, as in coastal Orissa, Uttar Pradesh and Bihar. In north eastern India, around 550 thousand ha is under shifting (Jhum) cultivation.

Rice cultivation is conditioned by temperature parameters at the different phases of growth. The critical mean temperature for flowering and fertilization ranges from 16 to 20°C, where as during ripening the range is from 18 to 32°C. Temperatures beyond 35°C affect not only pollen – shedding, but also grain filling. For vigorous vegetative growth, moderately high temperatures are required, whereas, for panicle initiation, slightly lower temperature (20 to 22°C) would be ideal. High temperatures and high light intensity adversely

affect grain filling. Rice can be cultivated best in soil having pH 5 to 8.5. This crop is known to be fairly tolerant to soil salinity crop, can grow normally in soil up to 6 mmhos/cm conductivity. Soils having exchangeable sodium percentage greater than 15 may adversely affect the growth.

Productivity of land used for the cultivation of rice is to a large extent determined by position of paddock on slope length and water conditions. The rice lands for cultivation and water management can be classified into three major groups (i) upland (Pluvial). (ii) medium land (Phreatic). (iii) low lands (Fluvial) and (iv) deepwater. Hence, water management is highly location specific issue.

In the upland there is no standing water in the fields 48 hours after cessation of rain. In the lowland, water depths ranging from 10-75 cm may stand in the fields during the crop-growing season, depending on the location of the field on the toposequence and the intensity and duration of rainfall. In spite of this water depth, some of these areas may also suffer from periodic dry spells. In deep water areas, water during the rice crop-growing season may be as deep as 1.5 m or 2.0 m. With the onset of monsoon, the rainwater starts collecting at the end of this catchment. Thus the lowest part of the lowlands gets saturated with water. The farmers take up direct sowing of paddy seed in such locations before the saturation occurs. At the same time, they start preparing nurseries for transplanting lowlands and considerable part of the medium lands. When the subsequent rains are received, the uplands are also sown directly with higher seed rate. Before the seedlings are ready, the remaining lowlands and considerable part of the medium lands are prepared for transplantation.

Upland: Almost 6 m ha of rice in India is estimated to be direct seeded in rainfed upland soils (Patnaik and Bhadrachalam 1985). The uplands are light soils and are not quite suitable to grow rainfed rice. They depend on rainfall for moisture. After the onset of monsoon, the uplands are sown directly with higher seed rate (up to 200 kg/ha). The upland rice does not receive the same attention as transplanted rice. Rice is still cultivated, as it is a prestigious and staple food crop. The crop is normally of 100 days duration. The upper reaches of upland are mostly unbunded. Bunding usually starts above medium land in uplands. The upland rice is grown without leveling. The lands are prepared dry. Normally, soils of this category have, under natural conditions, a free drainage, even during peak period of rain, with none to only weak signs of periodic water saturation in the profile. The duration of standing water would not exceed forty-eight hours.

Crop mostly suffers due to drought under prolonged rainless period. Rice yield is low and inconsistent. Water management mostly relates to in situ conservation and crop tolerance to soil moisture stress at different growth stages. Near field capacity condition during active growth period of the crop is ideal for achieving high yield as well as high water use efficiency. Further, moisture stress of even 0.5 bar at maximum tillering to flowering stage is most detrimental to growth and yield of the crop.

Medium Land: Medium lands or phreatic lands receive some runoff water from uplands during heavy rains. The lands are situated at low elevation and are mostly either rainfed or flood fed. Soils show sign of temporary water saturation in the profile leading to shallow depth (15-30 cm) of water stagnation with relatively low problem of either flooding and/or drought during monsoon season. These lands are best suited for scientific rice cultivation and easy water management.

Area under these land situations can be divided into two major groups, rainfed and irrigated. The depth of water seldom exceeds the level, which adversely affects the crop under rainfed situations. Transplanting is mostly followed. Raising nurseries for transplanting is started with the onset of monsoon. Land is prepared for transplantation before the seedlings are ready. A duration of 125-135 days transplanted crop requires 1.20 m to 1.55 cm of water, in sandy clay loam soil with permeability less than one cm per day. High yield is possible if shallow submergence of 5 ± 2 cm is restricted to tillering to early dough stage. Increased hydraulic head by increasing bund height results in increase in percolation and adds to groundwater. Under rainfed conditions, half of the total water use could be met by the shallow groundwater from 0.30 to 0.60 m.

Lowland: They occupy foothill slopes or valley plains where natural retention of surface water is practically nil because of the distinct gradient of the surface. Rainfed lowland rice may be considered as that part of the global rice-growing continuum in which the crop is not irrigated, but the soil is flooded for at least a fraction of the crop cycle with a maximum sustained water depth of 50 cm. Rainfed rice fields principally receive overflow

or runoff, depending on the intensity and duration of rainfall, from fields located at higher elevation and also catch and hold rainwater that creates or leads to waterlogged condition for most of the growing period of the crop. However, based on hydrology of location of the field, popularly lowlands are often classified as shallow, intermediate and semi-deep lowlands with water depth up to 30 cm, 30 cm to 50 cm and 50cm to 100 cm respectively (Huke, 1982). Drainage is very low causing the rice field to remain in the natural state of inundation or flooded most of the time during growing period of the crop.

A network of ditches constructed by the Govt. of Orissa during 1990-91 increased the drainage density in Kushbhadra-Bhargavi Doab from 0.51 km/km² to 0.78 km/km² (Panda et al 1994). The study revealed that drainage has modified the rice ecosystem by reducing the depth and duration of ponding, thereby decreasing the risk of paddy production. It induced the farmers to practice improved methods of rice production by adopting high yield varieties and enhanced use of chemical fertilizers. The increase in yield ranged from 29 to 140% and crop intensity from 75-160% depending on the location. The benefit cost ratio increased from 1.15 in pre-drainage period to 2.07 in post-drainage period. The analysis of productivity in the watershed of a drain due to 45% less occurrence of rainfall during 1990-96 revealed that the production has gone up taking into account considerably the potential of the area.

These are the most difficult land situations from the point of view of water management. With the onset of monsoon, the rainwater starts collecting at the end of this topo-sequence. Thus the lowest part of the lowlands gets saturated with water. The farmers take up direct sowing of rice seed in such locations before the rainy season sets. At the same time, they start preparing nurseries for transplanting in other upper parts of lowland. Before the seedlings are ready, these remaining lowlands are prepared for transplantation. Rice varieties are most susceptible to complete submergence at flowering followed by seeding establishment and late vegetative stages in that order. Submergence up to 50% plant height at any growth stage causes reduction in yield. However, the maximum reduction was when waterlogging prevailed at seedling establishment to tillering stage followed by tillering to flowering. This reduction was primarily due to suppression of tillers (Gharai and Singh 1994). The reduction in yield due to inundation at flowering is due to increase in sterility as a result of failure of pollination and fertilization of spikelets under water. Draining of water at least up to 25% of plant height at the critical stage is necessary for satisfactory and reasonable crop yield.

The transplanted lowland rice is the most important system that receives all the attention of the farmers. Attempts have been made mostly to find out variety tolerance to submergence of varying depths and duration, agronomic manipulation to overcome disasters and integrated farming practices to minimize no return risk in the event of crop failure. In areas that are exposed to developmental activities or in areas where inputs are available, the farmers tend to use external inputs like fertilizers and improve their productivity to the extent of their economic capabilities. Rice yields up to 2-2.5 t/ha were also reported from farmers fields (Singh et al., 1999).

Deepwater Area: These lands are located always in lower most parts of the landscape of the watershed in valley plain. The lowlands inundated by more than a meter water depth (Huke 1982). Such lands generally hold excess water for a period of 3 to 6 months during the monsoon months (July–October). The soil is mostly alluvial and relatively more fertile. Over the years, in such lowlands, monocropping with rice is generally practiced. The progress in increasing the production of rainfed rice has been slow with yields less than 0.5 t/ha. Many farmers are still using traditional varieties and cultural practices.

These are also flood prone and waterlogged lands causing the crop to suffer due to excess water. The flooded rice fields receive sometimes and retain water brought to them by rise in the level of streamlets, rivers etc. Such lowland areas (*diara lands*) are located in the present rainfed domain Baharich district of Uttar Pradesh. The land once flooded remains submerged due to ill-drained condition, for a very long time and sometime even up to the harvest of the crop. Thus such areas can be classified as areas of prolonged water logging and areas of flash flooding (Chaudhary 1997).

In northern hills of Chattisgarh the local names of unbunded uplands are *Dand*, *Tikra*; banded uplands are *Goda chawar*; medium uplands are *Chawar*; and lowlands are *Bohal*. In *Purulia* (West Bengal) the unbanded uplands are *Tanr*, banded uplands are *Baid*; medium lands are *Kanali* and lowlands are *Bohal*. Orissa has about 1.0 m ha rainfed rice area and a major portion of these lands is Western Orissa constituting the tribal dominated districts like Kalahandi, Koraput, Bolangir, Phulbani etc. Rice and millets are most important crops grown in rainfed upland. Productivity of upland rice is very low (0.6 t/ha) and whatever

little is produced is important as it provides food security to poor tribal farmers of that area. Adoption of improved technology is low. Uplands of Kalahandi are two types, unbunded (*Atta*) and banded (*Mal*). Crops under unbanded uplands are subject to drought at any crop growth stage. Duration of drought varies from 8.2 to 16.3 days.

Issues and strategies

Various production systems in different agro-ecoregions are given:

Agro-eco-region	State/ District(s)	Production system
Eastern plain, hot sub humid (moist) eco-region	Bihar Champaran (East)	<ul style="list-style-type: none"> Rice, wheat, maize, chickpea, pigeonpea, lentil, greengram, pea and bakhla (<i>Vicia saba</i>), rapeseed mustard, linseed, sesame, groundnut Rice-wheat, maize-wheat (rotations) in irrigated region Maize + pigeonpea common in uplands Rice-lentil and rice-barley-pea (rotation in low lands) Rice summer greengram in low lands
Eastern plateau (Chotanagpur) and Eastern ghats, Hot subhumid ecoregion	Jharkhand Hazaribagh Giridih, Ranchi (North-East)	Unbanded ($Tanr_1$, $Tanr_2$) and banded uplands ($Tanr_3$) <ul style="list-style-type: none"> Predominantly monocropped with rice (un irrigated) Medium (Don_3, Don_2) and lowlands (Don_1) Maize, wheat, chickpea, rice, pigeonpea are also grown. Khesari as paira crop
	Gumla, Hazaribagh Singhbum	<ul style="list-style-type: none"> Predominantly monocropped rice zone Single cropping (<i>kharif</i>-rice, maize, sorghum, pearl millet, finger millet, pigeonpea, niger, mesta, groundnut, vegetables) Double cropping (<i>kharif-rabi</i> – rice-linseed, rice-khesari, rice- chickpea)
Moderately to gently sloping Chattisgarh/ Mahanadi basin, hot moist/ dry subhumid	Chattisgarh Durg, Raipur, Balaghat, Rajnandgaon, Bilaspur, Raigarh	Unbanded (<i>Bhata</i>) and banded uplands (<i>Matasi</i>) <ul style="list-style-type: none"> Rice, millets (kodo millets-kutki) Medium (<i>Dorsa</i>) and low (<i>Kankar</i>) lands Rice, lathyrus, linseed, chickpea, wheat
	Bastar	Rice, millets (kodo, kutki, kulki, maize) followed by finger millet, sorghum, niger, blackgram according to land slope, soil type, agriculture practices and broad farming systems are organized <p>Protected lands (<i>Badi 1</i>)</p> <ul style="list-style-type: none"> House gardens, vegetables etc. Sloppy lands (<i>Marhan and Tikra</i>) – <ul style="list-style-type: none"> Millets (kodo, kuthi, finger millet, maize, niger) Rice is grown in lower reaches Levelled upland (<i>Mall lands</i>) <ul style="list-style-type: none"> Rice, maize, sorghum, kulthi Levelled banded low lands (<i>Chabar</i>) <ul style="list-style-type: none"> Long duration rice varieties, linseed, rapeseed mustard, kulthi with residual moisture in <i>rabi</i> season
	Surguja Madhya Pradesh Sidhi, Shahdol, Mandla	Rice, millets (koda, kutki) grown in gravelly and skeletal soils and maize in kolia soils Mustard, chickpea, sesame Highly undulating stony eroded lands <ul style="list-style-type: none"> koda, kutki, niger, toria

Agro-eco-region	State/ District(s)	Production system
		Upland unbanded (<i>Goda/ Tikra</i>) situation <ul style="list-style-type: none"> • Early maturing varieties, rice, blackgram, kutki, niger, pigeonpea and maize. • During <i>rabi</i> only toria is grown in <i>bari</i> condition
		Upland banded (<i>Goda chawar</i>): Bunding of upland fields. <ul style="list-style-type: none"> • Early varieties of rice, groundnut, soybean, maize, vegetable and fruit crops • Low land banded (<i>chawar</i>) • Rice - wheat/ mustard (irrigated) • Rice – chickpea/ linseed/ lentil (rainfed)
		Extreme low land (<i>Bahara</i>) <ul style="list-style-type: none"> • Monocropping of rice is generally followed
		Large bunds (<i>Bandhan</i>) (<i>Shahdol</i>): <ul style="list-style-type: none"> • <i>Rabi</i>: • Rainfed wheat in lower portion • Chickpea/ linseed in upper portion
Central high lands (Malwa and Bundelkhand), hot subhumid (dry) eco region	<i>Madhya Pradesh</i> Jabalpur, Panna, Satna	Haveli system <ul style="list-style-type: none"> • <i>Kharif</i> fallow (for storing water) - <i>Rabi</i> crop
	Rewa, Seoni	Banded uplands: <ul style="list-style-type: none"> • Rice – pigeonpea / chickpea; rice – wheat; millet based farming; undulating lands with higher soils.
		Unbanded uplands: <ul style="list-style-type: none"> • Rice, maize, sorghum, pigeonpea, greengram, blackgram, sesame, niger, kulti linseed, mustard
		Banded uplands: <ul style="list-style-type: none"> • Rice (early medium duration), Kodo, Kutki, maize, <i>rabi</i> sorghum, pulses and sesame
		Banded low lands: <ul style="list-style-type: none"> • Rice – wheat/ chickpea / mustard/ linseed.
		Large bund (<i>Bandhara</i>): <ul style="list-style-type: none"> • <i>kharif</i> fallow – wheat + chickpea
	Damoh	Upland: <ul style="list-style-type: none"> • <i>kharif</i> crops
Deccan plateau, hot sub-arid eco-region	<i>Karnataka</i> Belgaum Dharward	<ul style="list-style-type: none"> • <i>Rabi</i> sorghum, <i>kharif</i> sorghum, chickpea, pigeonpea, small millets, groundnut, pearl millet, cotton, greengram, blackgram
Deccan plateau, hot sub-arid eco-region	<i>Maharashtra</i> Kolhapur Pune	<ul style="list-style-type: none"> • <i>Kharif</i>: Pearl millet, sorghum, pulses, groundnut • <i>Rabi</i>: Sorghum, safflower, chickpea • Sheep and goat- Animal component
	Bhandara	<ul style="list-style-type: none"> • Rice – <i>Rabi</i> pulses / linseed • Rice- <i>Rabi</i> sorghum/ <i>Rabi</i> pulses
	Chandrapur	<ul style="list-style-type: none"> • Cotton, <i>kharif</i> sorghum + pigeonpea, <i>Rabi</i> sorghum, wheat, rice, sesame • Rice – <i>Rabi</i> jowar / pulses / oilseeds. • <i>Rabi</i> sorghum – Rice
Eastern plateau (Chottanagpur) and Eastern ghats, Hot subhumid ecoregion	<i>Orissa</i> Sundargarh	Upland: <ul style="list-style-type: none"> • Single cropping- Groundnut/ pigeonpea/ Blackgram/ Cotton/ sorghum/ Maize/Castor/ Niger/ Mesta. The main cultivated cotton variety is LRA-5166. • Mixed cropping- pigeonpea + rice; pigeonpea + Groundnut; Cotton + Greengram; Castor + Greengram • Sequence cropping- Rice-Horsegram/ Mustard; greengram-Niger; Maize-Mustard; Rice-Castor

Agro-eco-region	State/ District(s)	Production system
		Medium Land:
		• Sequence cropping- Rice-mustard/ linseed/ chickpea
		Low land:
		• Sequence cropping- Rice-Bengalgram/ pea/ lentil/ linseed
	Mayurbhanj	Upland:
		• Monocropping- Groundnut/ pigeonpea/ maize/ greengram/ blackgram/ castor
		• Sequential cropping – Groundnut, maize-horsegram, groundnut-castor
		• Mixed cropping- pigeonpea + rice, pigeonpea + finger millet, pigeonpea + groundnut, pigeonpea + maize
		Medium land:
		• Sequential cropping- rice-mustard, rice-greengram/ blackgram, rice- chickpea, rice-safflower
		Low land:
		• Relay cropping- Rice-field pea (Pyra crop), C.V-T-163
	Keonjhar	Upland
		• Monocropping: Groundnut/ pigeonpea/ finger millet/ maize// castor/ maize/ cotton/ sorghum/ greengram/ blackgram/ niger/ sesame/ Jute (Anandapur)
		• Mixed cropping: pigeonpea + rice, pigeonpea + groundnut; pigeonpea + finger millet, maize + greengram; castor + greengram; cotton + greengram
		• Sequential cropping: Rice-horsegram/ greengram/ blackgram; Groundnut-horsegram/ greengram Jute-greengram/ blackgram
		Medium land
		• Sequential cropping- Rice- Mustard/ chickpea/lentil/ linseed/ safflower
	Balasore, Keonjhar	Upland
		• Mung/ pulses/ cowpea
		• Finger millet-mustard/greengram
		• Maize/sorghum-horsegram
		• Groundnut + pigeonpea
		• Mung + pigeonpea
		• Rice + pigeonpea
		Medium land
		• Rice-mustard
		• Jute-rice-mustard
		• Jute-rice-mung/ Biri
		• Rice-groundnut/castor/mustard
		• Rice-Biri/ Fieldpea
		• Rice-wheat
		Low land
		• Jute-Rice-Pulses
		• Rice-Biri/ mung
	Cuttack, Puri	• Early wheat – chickpea
		• <i>Capsularis</i> jute – Rice – Pulse
		• Rice – Pulse / G.N
		• Rice – Potato – til
		• <i>Oiltorius</i> jute – wheat – greengram
		• Early rice – cauliflower / cabbage / okra
		• Early rice – cauliflower / cabbage / okra

Agro-eco-region	State/ District(s)	Production system
	Phulbani	<p>Brown forest soil, high rainfall, and high elevation</p> <p>Upland (Podar, Dhipa)</p> <ul style="list-style-type: none"> • Single crop of rice/ ginger/ turmeric/ tapioca/ pigeonpea • Monsoon potato/ tomato • <i>P. miliare</i>—Niger • Finger millet-Niger <p>Medium land (Majhya)</p> <ul style="list-style-type: none"> • Single crop of rice • Maize-Mustard <p>Low land (Khalla)</p> <ul style="list-style-type: none"> • Single crop of rice • Laterite soil, moderate rainfall and high irrigated situation <p>Upland</p> <ul style="list-style-type: none"> • Single crop groundnut / brinjal· Finger millet + Cow pea – Horsegram • Maize – Mustard <p>Medium Land</p> <ul style="list-style-type: none"> • Sesame – Rice • Rice (HYV) – Greengram / Lathyrus • Rice – Vegetable • Pre – rice Finger Millet / sesame / Sunhemp – Rice <p>Low land</p> <ul style="list-style-type: none"> • Single crop rice (local) • Groundnut/ Lathyrus <p>Red loam soil, low rainfall, moderate elevation in moderate irrigated situation</p> <p>Upland</p> <ul style="list-style-type: none"> • Rice-Greengram/ Blackgram/ Horsegram • Finger millet-Niger • Single crop Groundnut/ Maize/ Cotton/ Tobacco • Maize-Mustard <p>Medium land</p> <ul style="list-style-type: none"> • Pre-rice Finger millet Mesta-Rice • Sesame-Rice • Single crop cotton <p>Low land</p> <ul style="list-style-type: none"> • Single crop rice • Rice-Pulses
	Koraput, Kalahandi	<p>Upland</p> <ul style="list-style-type: none"> • Finger millet (Monocrop) • Rice (Monocrop) • Niger (Monocrop) • Kulthi (Monocrop) • <i>P.Milliare</i> (Monocrop) • Maize (Monocrop) <p>Medium Land</p> <ul style="list-style-type: none"> • Vegetables • Rice-Maize • Rice-Finger millet • Maize-Vegetables • Rice-Lentil • Rice-Wheat-Biri

Agro-eco-region	State/ District(s)	Production system
Northern plain, hot sub-humid (dry) eco-region	Uttar Pradesh Kheri, Sitapur, Allahabad	Low Jhola Land
	Faizabad, Sultanpur, Pratapgarh, Azamgarh, Ballia	<ul style="list-style-type: none"> • Rice-Monocrop • Rice-Rice • Fallow-Niger/ pulses in rainfed medium lands • Potato, ginger, niger, mesta, sunhemp, cotton, jute, sweet potato, onion, <i>setaria italica</i> in plain lands • Wheat, rice, chick pea, sorghum, pearl millet, barley, pigeonpea, rapeseed mustard, groundnut • Rice, sugarcane, maize, pigeonpea

Issues arising under different agro-ecologies of upland and lowland and possible strategies thereof in rainfed rice for different eco-regions are described.

Strategies		
Issues	Upland	Lowland
Characterization of the agro-eco system	<ul style="list-style-type: none"> • Rice is a prestigious crop of the region and is considered as lifeline. Rice is grown in a variety of agro-climatic conditions. Water deficit becomes more critical at the reproductive stage than during the vegetative stage. For high quality aromatic varieties of rice with fine grains, cloudiness and low temperature during maturity are favourable factors. For other varieties, continuous sunshine and high temperature and water availability during the growing season. However, temperature may not affect the yields in lowlands. • The rainfed ecosystems were identified and assessed as per the location on the slope length. Rice is more suitable for medium and low lands. • The tenancy is such that the farmers more often are not the owners of the land. Consequently, the interest of the farmers in management of natural resources is lacking. Incentive based motivation of the tribal and other farmers may be needed. • Low soil fertility due to soil erosion leading to losses of soil nutrient and moisture and low and imbalanced use of fertilizers. This may be overcome by bunding. • The input supply, transport system and marketing needs improvement to improve the poorer economic situation of hinter lands. • In regions receiving more than 1000mm mean annual rainfall, the soils are generally coarse-textured and acid. While in regions with lower rainfall, soils are heavier and neutral to alkaline. Most rice growing states in the country has same area under upland rice both on acid and alkaline soils. • Bunding work by State Department of Agriculture of unbunded uplands may be helpful to reduce degradation. 	<ul style="list-style-type: none"> • Quantification of emission of radiatively active (green house) gases from lowland land rice is essential for environmental production and related policy issues. • Ferrous ion concentrations above 300 ppm have been measured in the solutions of several soils in West Bengal and North-eastern states. In Assam it is particularly serious in Nagaon, Jorhat and Sibsagar districts. Rice leaf samples were reported to contain 428-560 ppm total Fe as compared to a critical concentration of 300 ppm. Iron toxicity by itself is a rather complex problem and is often related to insufficient supply of phosphorus, potassium, zinc and sometimes calcium and magnesium rather than just a high level of active iron. Balanced nutrition and drainage are important aspects covering various facets of rice cultivation.
Improving the water use efficiency for increased productivity	<ul style="list-style-type: none"> • Agro Eco System needs to be devoted on watershed approach. • Moisture stress due to erratic and often-inadequate rainfall, high runoff, degraded poor available holding capacity poor soils and lack of soil moisture conservation and lack of facilities for rainwater storage and life saving irrigation in upland and drought-prone lowlands are common problems. 	

Issues	Upland	Lowland
	<ul style="list-style-type: none"> In the uplands where water does not accumulate, the rice crop is more vulnerable to the vagaries of the rainfall like delayed onset, early withdrawal, breaks in the monsoon etc. Rainwater harvesting through on-farm technology has made significant improvement on the productivity of rainfed rice as well as in cropping intensity, but on a limited scale. Technology can be promoted on watershed basis. Flash Flood 	<ul style="list-style-type: none"> Intermittent moisture stress, due to low and erratic rainfall, and poor soils as in MP, Orissa and some parts of UP and flash floods, water logging/ submergence due to poor drainage, low lying physiography and high rainfall in submergence prone lowlands, as in Assam, West Bengal and North Bihar. Accumulation of toxic decomposition products in ill drained soils and soil reduction, encouraging problems of iron toxicity in Assam. Drainage needs attention on watershed/ area/region basis. North Bihar interspersed with inter-connected tanks (<i>chaurs</i>). The inter-linked hydrology gives rise to complex and high risk (flood prone) ecology. The <i>chaur</i> fall in the medium-stream of a natural drainage course between a tributary of Gandak river and the Ganges. Similar is the situation in Raipur, Chattisgarh Plateaus. Man induced interventions in the downstream have created impediments in the natural drainage. Farmers feel that the water regime in the tanks also changed. Consequently, indigenous set of technology, which used to provide low but stable yield have become unpredictable. Flood water and deep standing water management need to be tried in areas of absence of adoption outlet by injecting water into aquifers without affecting the quality of ground water. The water may be pumped out from drainage wells for an assured summer crop and for creating pockets ready for replenishment in problem periods. Feasibility for a second crop is established but needs refinements. Rainwater harvesting and reuse for improving the income through a definite second crop (with (come up irrigation) needs greater attention considering the immense scope.
To improve Crop yield ceilings	<ul style="list-style-type: none"> Preservation of genetic diversity in rainfed rice is needed. Continuous use of traditional varieties due to non-availability of improved seeds and farmers lack of awareness about high yielding varieties in upland and lowlands. A number of promising varieties have been identified for specific situations in the Rainfed Eco Systems. Varieties of rice of different durations (90-135 days) were identified for the toposequence. The present demonstration yield levels are 2.5 to 4 t/ha. Multiplication of seeds of high yielding promising varieties for specific areas, like rainfed upland and lowland by the seed producing agencies and making it available to the farmers can play a very significant role in enhancing the productivity of rainfed rice. Varieties for deep-water areas are not promising. In this regard, Golden rice of high quality needs attention in these mal-nourished tribal areas. Use of photosensitive varieties that flower between the third week of October and the second of November. Short to medium duration stress resistant varieties. Superfast rice may also hold promise. The ideal upland rice plant type with higher yield potential is envisaged to be about consideration. 	<ul style="list-style-type: none"> Medium to long duration stress resistant through submergence tolerant floating rice cultivars needs 130cm tall with 5-8 tillers and very few

Issues	Upland	Lowland
To improve the productivity of different cropping systems	<p>unproductive tillers, sturdy stems, large panicles each with 150-200 grains, thick root system, 100-110 days growth duration, durable resistance to blast and adaptation to poor acid soils.</p>	<ul style="list-style-type: none"> • The ideal high yielding rice plant type for these conditions is conceived to be 130 cm tall with sturdy stems, dark green and erect leaves, 6-10 productive tillers, very few unproductive tillers, panicles with 150-200 grains. Such plants must also have resistance to diseases and insects, and tolerance to drought and flooding. The plant type needs to be more responsive to inputs. Varieties presently grown yield 2-3 t/ha. Target should be to raise the yield potential to 4-5 t/ha. The favourable gene combinations for yield stability needs retention. • Major challenge in deep water rice breeding is to develop varieties with a harvest index of 0.3 and average yields of 4.5 t/ha. Improved plant types for deep water must have stem elongation ability, 5-7 panicles each with 150-200 grains, upper nodal rooting and tillering ability, photoperiod sensitivity, grain dormancy, drought tolerance at seedling stage and resistance to stem borers. • In the jute-rice system, jute needs development of short duration plant type with high productivity and quality, use of multilane, multi-cross varieties, resistance pests and diseases, and high efficiency to convert photosynthate to fiber. Development of matching with high yields for relay and post monsoon. Improving the yields of relay crop and dry season crops need attention.
	<ul style="list-style-type: none"> • The dates of onset and withdrawal of the monsoon and distribution of rainfall greatly influence the choice and variety and sowing time. • The availability of quality seed and demonstrating the potential of the varieties to a large number of farmers needs immediate attention. • In case rice has to be grown in the uplands, intercropping with pigeonpea is remunerative. • Line sowing to ensure optimum plant population and to enable easy and inexpensive eradication of weeds. • Uplands are more suitable for crops like finger millet, maize, groundnut and blackgram than rice. 	<ul style="list-style-type: none"> • Poor crop stand establishment due to broadcast seeding, resulting in uneven germination. Delay in monsoon onset, often leading to delayed and prolonged transplanting and sub-optimum plant population. Transplanting in the lower end of the slope is useful. • Using 20% higher seed rate and 20% more fertilizer in shallow lowland areas, where crop failures are uncommon. • Boro rice Technology has been very promising and is becoming popular in West Bengal, Assam and North Bihar and Eastern districts of UP. The average rice yields have been about 5-6 t/ha. This can be suitably popularized in identified area. • Presently rice nurseries are prepared only with the onset of monsoon. Nurseries raised on community basis, 3 to 4 weeks ahead of the monsoon rains with the shallow wells can help to utilize potentially available moisture availability period. Agronomy for getting higher production and optimum plant stand under '<i>utera/piara</i>' systems is needed.

Issues	Upland	Lowland
Improve soil fertility and residue management	<ul style="list-style-type: none"> • Traditionally transplanted and parts of direct sown rice is harvested by taking off earheads and leaving straw in the field. Animals are then allowed to browse. In the process, the dung, urine and other droppings add as nutrients in the field. With the onset of rains in the subsequent season, whatever biomass is left over, is ploughed back into the soil and allowed to decompose anaerobically. This is an indigenous chain recuperation system under subsistence farming. • Jute based cropping system is ideal for maintaining status of soil-organic matter due to continuous fall of jute leaves (2.63% N, 0.81%, P₂O₅, 2.42% K₂O) during growing period, shedding of leaves after harvest and left over roots in the soil. • After the jute harvest, a sizeable amount of crop residue (1.47 to 2.55 t ha⁻¹) in the form of root, stubble and leaf fall was incorporated in the soil. The natural recycling of organic matter in jute helps in maintaining the soil nutrients to be subsequently used by rice in jute based cropping system. The dynamics needs quantification. • Quantification on nutrient balance and organic matter changes with legumes and oilseeds in rotation with rice in relay double cropping system are needed. • Effectiveness of <i>sa/</i> leaves used by farmers, as green leaf manure needs quantification to avoid confrontation between trial farmers and forest officials. Alternations may be found out. • Moderate (50 N:25 P₂O₅: 25 K₂O) application of fertilizers. Phosphorus and potash as basal before sowing. It is advantageous to skip the basal N application due to weed problem and apply it in small splits at 10-15 day intervals after weeding. Nitrogen in two splits – 50% of N 2-3 weeks after germination and top dressing the remaining at 2-3 week intervals, depending on seasonal conditions. Nutrient management systems have been largely through external supply of fertilizers. Less emphasis was placed to integrated nutrient management by using locally available research. 	<ul style="list-style-type: none"> • Variety rescheduling for better economics of jute. <i>Biasi</i> needs attention on faulty method of sowing, improper time due to uncertainty of rain, faulty method of ploughing and proper selection of variety. • Application of fertilizer to seedbed to ensure robust and healthy seedlings for quick establishment and withstanding short periods of submergence. • Application of N and P as basal dose either by incorporation or by hand placement so as to ensure early growth vigour. • <i>In situ</i> green manure with <i>Sesbania rostrata</i> was termed to be success in low input agriculture. • Non-availability of any suitable method to apply the fertilizer in standing water in rainfed lowland, semi-deep and deep water areas. • Emphasis on balanced use of plant nutrients along with the popularization of integrated nutrient management approaches. • Application of urea super granules through mechanical devices has shown a high promise in increasing crop yields and nutrient use efficiency. This technology needs a large-scale demonstration on farmers fields in rainfed regions. The provisions of urea super granule production and the fabrication of urea super granule applicators for masses to derive the benefits of technology. • In Orissa, application of 60kg K₂O/ha was reported to correct iron toxicity. • Improper soil physical conditions for <i>biasi</i> may be overcome through Integrated Plant Nutrient Management / Green Manure (IPNM/GM) incorporation • In jute-rice system, relay cropping and double cropping, fertilizer scheduling needs attention for targeting the land productivity by avoiding nutrient mining.

Issues	Upland	Lowland
		<ul style="list-style-type: none"> • Need for efficient tillage/cultural practices for good seed bed preparation in rice fallow.
To improve Soil Quality and Resilience	<ul style="list-style-type: none"> • Assess soil quality and degradation problems of soil and water resources for their impact on production losses. • Development of regional watershed plans and methodologies for identification of critical areas for prioritized land treatment in the watershed. • Develop and refine technologies for rehabilitation of marginal and other degraded soils for prioritized treatment of areas in watersheds. 	
To reduce losses due to pests, weeds and diseases by integrated management	<ul style="list-style-type: none"> • Poor attention for their timely control heavy infestation of insect and pests such as blast and brown spot. • Absence of community action. • Control storage pests in humid environment. • Quantification on critical incidence based on crop economics. A relating incidence to agroclimatic variables. • Real time forewarning systems of control, weather advisories • State seed bed preparation practices combined with pre-emergence application of effective weeding and weeding schedules 	<ul style="list-style-type: none"> • Propagation of Integrated Pest Management approach for the control of pests and diseases. • Weed control through Integrated approach in <i>biasi</i>.
To improve field capacity by improved Implements	<ul style="list-style-type: none"> • The persistent lack of adequate draft power and the needed corrections have not been fully addressed. Design and development of improved tools and implements for tilling and cultural operations. Manufacture of the improved implements by local artisans needs examination. • Almost 6 m ha of rainfed rice in India is estimated to be direct-seeded. Improved implements for <i>biasi</i>/bushening are needed in this area. • Multi line seed-ferti drills in upland only. 	<ul style="list-style-type: none"> • Encouraging the use of improved farm implements for effective and timely field operations. • In <i>biasi</i>, faulty plough-shape needs improvement; Dependency on heavy rain for the operation and mechanical weeding may be reduced through efficient implements.
To Integrate and diversify land use	<ul style="list-style-type: none"> • Pigs, fishes, duckery etc., are the integral component of the production system. Too few attempts have been made for sustainable mixed farming. • Use of perennial species like jackfruit, ber, mango, custard apple, multipurpose trees etc. • Integrated land use for cattle based dairy farming round the year. • Pigs are the integral component of the production system. • Expansion of castor bean based Eri silkworm popularization • Indigenous cottons 	<ul style="list-style-type: none"> • Vegetable cultivation needs more attention in the farming systems perspective. • Develop intercropping in horticultural crops like litchi, sweet potato, mango, etc. • Available standing design and technology for sustain- able rice-fish integration in low and medium lands to improve the socio economic rural poor.
status of Post Harvest Value Addition (PHVA)	<ul style="list-style-type: none"> • Marketing storage and Post-harvest Value Addition for increased marketability is poorly attended. 	
Socio-economic Policies	<ul style="list-style-type: none"> • The economic disparity amongst the farming community is high that warrants development of technological options and graded technology diffusion to suit the economic conditions of different farming communities. • Poor adoption of improved crop production technologies due to technology inappropriateness and economic backwardness of the farmers. Organization of field demonstrations of improved technological packages in specific situations and training of the farmers for effective transfer of newly developed crop production technologies. • Suitable technological packages for different ecosystems by states in Eastern India. In order to fully implement the program and to derive the benefits of the improved technologies, farmers from hinterlands who apply it, need to be trained on various aspects. These needs have to be incorporated along with transport and marketing avenues in the future work plans on a continuous basis. 	

Issues	Upland	Lowland
	<ul style="list-style-type: none"> Ensuring timely and adequate availability of inputs like seeds, fertilizers, credit etc., to the farmers. 	<ul style="list-style-type: none"> Socio economic constraints in “<i>biasi</i>” system may be overcome through enhancing skill

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

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

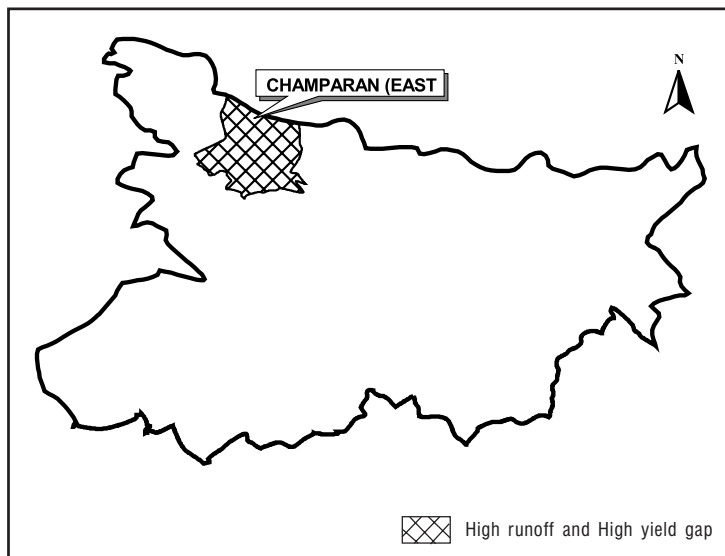
The productivity (average yield 1990-91 to 1994-95) and annual rainfall (mean of past 30 years) were used for yield gap analysis, which is 0.7 of achievable yield based on water requirement satisfaction index. The yield gap was grouped as low (< 33%), Medium (33-66 %) and high (>66%). The possible options are–

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

The available recommendations from network of research of National Agricultural Research System (NARS) were linked to the matrix of yield gap and surplus index. Recommendations are given for crop based production system, state-wise and group (s) of districts. These consist of soil and water conservation, crop management (varieties, seed rate, planting pattern, nutrient management, pest management, suitable cropping systems, implements, alternate farming systems, contingent planning. A region was described in terms of agro-ecological setting, physiography, soils, climate, annual rainfall, PET and moisture availability period. The identified priorities for increasing the productivity in short term are also included. The recommendations on this crop based production system are given below state and district-wise in alphabetical order:

BIHAR

In Bihar there is one district viz. Champaran (East) under high runoff and high yield gap region.



The setting and recommendations follow:

District	Region
Champaran	High runoff and High yield gap

Agro-ecological setting

- **Agroecological sub region no :** 13.1
- **Climate:** Hot moist / dry subhumid
- **Physiography:** (Eastern plain) North Bihar
- **Soils:** Deep loamy alluvium derived soils (Inceptisols – 100%)
- **Annual rainfall:** 1216 mm
- **Potential evapotranspiration:** 1331 mm
- **Moisture availability period:** 180 –210 days

Soil and water conservation

- Sowing across the slope
- Contour farming
- The fields must be bunded to conserve soil moisture in uplands

Crop management

- **Varieties:** Brown Gora 23 –19, Vandana, Kalinga-III, Birsa dhan 101, Anjali
- **Seed rate:** 100 kg/ha
- **Planting pattern:** 20 cm inter row and thick intra sowing

- **Nutrient management**

- HYVs: 60 kg N+ 30 kg P₂O₅ + 20 kg K₂O/ha.
- Local: 30 kg N + 20 kg P₂O₅ + 20 kg K₂O /ha.
- Apply N in three splits at 20, 35, 45 days after sowing. Give top dressing post heavy rains. Basal application helps fighting drought. Apply Phosphorus in deficient soils

- **Pest management**

- Off-season tillage and use of wide blade harrow
- 1.0 kg Machete as pre-planting incorporation + 2.7 kg a.i./ha Stam F – 34 as post emergence for chemical weed control.
- Blast: Spray Bavistin (0.05%) or Hinosan (0.1%)

Suitable cropping systems

- Rice (Brown Gora) + pigeonpea (4:1), pigeonpea 75 cm apart
- Rice (Vandana) + pigeonpea (4:1) where pigeonpea is sown 75 cm apart

Alternate farming systems

Denuded eroded, highly sloppy and shallow lands

- Social forestry, silvipasture
- Fodder/green biomass: Social forestry, farm forestry and establishment of pasture crop

Deeper and light textured uplands

- Crops: Groundnut, soybean, finger millet, maize, sorghum, pigeonpea, blackgram, greengram, sweet potato, sesame, niger, horsegram

Uplands

- Horticulture: Mango, litchi, guava, lemon, custard apple, jack fruit, phalsa, jamun, ber, fig, bael
- Silviculture: *Subabul*, *B.monosperma*, *A. indica*, *D.sissoo*, *A.procera*, *Pongamia pinnata*, *B. variegata*
- Medicinal and aromatic plants: *Ravoulfia serpentina*, *Palma rosa*, *Vetiveria zyzanoides*, *Papaver somniferum*
- Vegetables: Bottle gourd, ridge gourd, bitter gourd, water melon, cowpea, brinjal, okra, *Papaver somniferum*
- Animal component: Female and male cattle, female and male buffaloes, sheep, poultry

Farm implements/ tools

- Bullock drawn 2 row seed cum fertilizer drill: For seeding dryland crops and fertilizer (Rs.1500/- per unit)
- Bullock drawn ridger (single row): For seeding when 8-10 cm topsoil gets dry. But soil moisture is available below this depth. Seed metered by hand (Rs.100/- per unit)

Contingent crop planning

Normal sowing period (15th to 30th June)

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

- Rice: Brown Gora. 23-19, Vandana, RAU. 4045 – 3, Anjali, Kalinga-III
- Finger millet: A. 404, PR. 202, IE. 723 (direct seeding as well as nursery sowing of all the 3 varieties)
- Maize: Ganga Safed. 2, Ganga. 5, Suwan-1

- Sorghum: CSH. 5 and CSH. 6
- Groundnut: AK. 12-24, Birsa Groundnut-1, BG. 1, BG.2, Birsa bold
- Soybean: Birsa Soybean- 1, Bragg
- Pigeonpea: BR. 103, 65, UPAS- 120
- Greengram: Sunaina
- Blackgram: T- 9
- Intercropping: Pigeonpea + rice, pigeonpea + maize, pigeonpea + groundnut, pigeonpea + 2 rows finger millet, pigeonpea + blackgram/greengram, (two row) pigeonpea + 2 rows soybean.

If the onset is delayed but is expected within a week or 10 days of normal onset date – Dry seeding of all the rice and groundnut varieties mentioned above in mid June

Delayed sowing period (1 – 7 July)

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

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

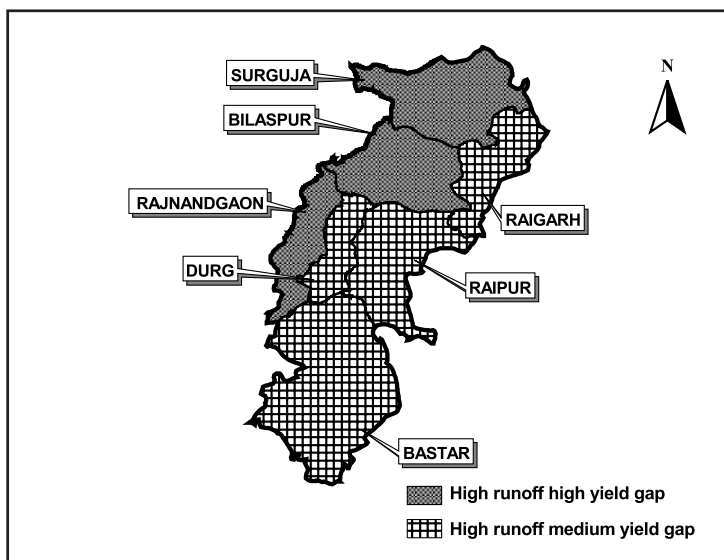
- Transplanting of finger millet (all varieties) but spacing to be reduced from 20 x 15 to 20 x 10 cm
- Greengram: Sunaina
- Blackgram: T.9
- Sesame: Kanke white (normal sowing time), Krishna
- Sweet potato: Cross 4 and Local (normal sowing time)
- Beyond July it is much too late for general crops. However, if seedlings are available transplanting of finger millet could be resorted to in early August. Niger (N.5) and horsegram (BR. 10 Madhu) are the natural choice for August seeding

General precautions in case of delayed sowing

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

CHATTISGARH

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



The setting and recommendations follow:

District	Region
Bastar Durg Raigarh Raipur	High runoff and Medium yield gap

Agro-ecological setting

Bastar

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

Durg

- **Climate:** Hot moist/ dry sub humid
- **Physiography:** Dhandakaaranya (Eastern plateau)
- **Soils:** Deep loamy to clayey red and yellow soils (Alfisols – 60%; Alfisols/ Ustolls – 40%)

- **Annual rainfall:** 1277 mm
- **Potential evapotranspiration:** 1651 mm
- **Moisture availability period:** 150-180 days

Raigarh

- **Climate:** Hot dry sub humid/ Hot moist/ dry sub humid
- **Physiography :** Chattisgarh / Mahanadi basin
- **Soils:** Medium and deep clayey black soils, shallow loamy black soils, deep loamy to clayey red and yellow soils (Alfisols/ Ustolls – 100%)
- **Annual rainfall:** 1628 mm
- **Potential evapotranspiration:** 1492 mm
- **Moisture availability period:** 150-180 days

Raipur

- **Climate:** Hot moist/ dry sub humid
- **Physiography:** Chattisgarh / Mahanadi basin
- **Soils:** Deep loamy to clayey red and yellow soils (Ustalfs – 50%; Alfisols – 25%; Vertisols – 15%)
- **Annual rainfall:** 1388 mm
- **Potential evapotranspiration:** 1723 mm
- **Moisture availability period:** 150-180 days

Soil and water conservation

Bastar

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

Raigarh

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

Durg, Raipur

- Sowing across the slope
- Contour farming

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

Crop management

Bastar

- **Varieties:**
 - **Uplands (*marhan and tikra*):**
 - Extra early maturity - Vanapraha, Heera, Aditya and Kalinga-III
 - Early maturity - Annada, Tulsi
 - **Mid land (*mal*):**
 - Medium maturity - IR 36, Abhaya, Kranthi, Madhuri, Pusa Basmati and Mahamaya.
- **Seed rate:** For broadcasting- 100 kg/ha; for drilling – 80 kg/ha
- **Planting pattern:** 22.5 cm rows
- **Nutrient management:**
 - 40kg N + 40 kg P₂O₅ /ha.
 - If rainfall is low, all P as basal and N in three splits viz., 50% at sowing, 25% at tillering and 25% at panicle initiation
 - If rainfall is good, 80 kg N in three splits viz., 25% at sowing, 50% at tillering and 25% at panicle initiation
- **Pest management:**
 - Gundhi bug: Methyl Parathion 2% dust @ 20-25 kg/ha
 - Green hopper: Carbofuran 3 g @ 15 kg/ha and Monocrotophos 400 g a.i. /ha.
 - Climbing cutworm: Endosulfan 600 g a.i /ha Malathion 0.055 at evening
 - Leaf blast: Hinosan 1 ml/l of water/ Bavistin 1 g/l of water
 - Bacterial leaf blight: Soak seeds in 0.025% water solution of Agrimycin + 0.03% wettable sulphur for 12 hours and then transferring the seeds to hot water at 52-54% 0C for 30 minutes.
 - Khaira: 2 kg ZnSO₄ and 1 kg slacked lime 2 spray 10 days interval, immediately after the symptoms are noticed.
 - Weed control: Complete hand weeding early in the first 30 days after sowing with khurpi and wheel hoe Butachlor @ 2 l as pre emergence in broadcasted rice

Durg, Raigarh, Raipur

- **Varieties:**
 - Uplands: Prasanna, Kalinga-III, Govind, IR-50, JR-3-45, Vandana
 - Lowlands: JR-353, IR-36, Jaya, Kranthi, Mahamaya, Karnal Basmati
- **Seed rate:** For broadcasting- 100 kg/ ha; For drilling – 80 kg/ha

Suitable rice varieties for light soils

Variety	Duration (days)	Description
Kalinga-III	85	Extra early maturing variety, tall, suitable for direct seeding. Due to early vigours, it can compete with weed population. It has long slender grain.
Vanaprabha	90	Early duration, tall and blast tolerant.
Aditya	90	Early duration, semi dwarf and blast resistant
Annada	105	Early duration, semi dwarf, drought tolerant and suitable for direct seeding and line sowing, It has short bold grain.
Tulsi	105	Early maturing, semi dwarf blast resistant with medium slender grain.
Poornima	105	Early duration, semi dwarf, suitable for banded upland condition, long slender grains, good milling quality.
Rasi	110	Early duration, resistant to blast, suitable for banded upland condition with medium slender grain.

Rice varieties suitable for drought prone rainfed area

Soil type	Suitable Duration (days)	Varieties	Maturity (days)
<i>Bhata</i>	80-90	Vanaprabha	90
		Kalinga-III, Vandana	85
		Aditya	90
<i>Matasi</i>	90-110	Tulsi	105
		Poornima	105
		Annada	105
		IR 64	110
<i>Dorsa</i>	110-130	IR 36	115
		Karnti	128
		Mahamaya	130
		Abhaya	125
<i>Kanhar</i>	130-140	Kranthi	128
		Mahamaya	130
<i>Bahara</i>	140-150	Safri 17	140-145
		Mahsuri	140-145
		Swarna	140-145

Suitable rice varieties for special situations

- Gallmidge endemic areas - Mahamaya, Surekha, Phalgun, Ruchi and Abhay.
- Blast endemic areas - Abhay, Aditya, Tulsi and Rasi
- Wild rice (*Karga*) - Shyamla
- *Bahara* land - Safri - 17, Mahsuri, Swarna
- Scented varieties - Madhuri, Pusa basmati
- Drought prone areas - Annada, Kalinga-3, Kranthi, Tulsi, Aditya, Poornima, Mahamaya.

- **Pest management**

- Gundhi bug: Methyl Parathion 2% dust @ 20-25 kg/ha
- Green hopper: Carbofuran 3 g @ 15 kg/ha and Monocrotophos 400 g a.i.
- Climbing cutworm: Endosulfan 600 g a.i /ha Malathion 0.055 at evening
- Leaf blast: Hinosan 1 ml/l of water/ Bavistin 1 g/l of water
- Bacterial leaf blight: Soak seeds in 0.025% water solution of Agromycin + 0.03% Wettable Sulphur for 12 hours and then transferring the seeds to hot water at 52-54% 0C for 30 minutes.
- Khaira: 2 kg ZnSO₄ and 1 kg slacked lime 2 spray 10 days interval, immediately after the symptoms are noticed.

- **Weed control:**

- Complete hand weeding early in the first 30 days after sowing with khurpi and wheel hoe.
- Butachlor @ 2 l as pre-emergence in broadcasted rice

Suitable cropping systems

Bastar

Sequence cropping

- Maize - *toria*

Inter cropping:

- Rice + blackgram (2:1) (MW.10) (T-9)
- Rice + groundnut (1:1) (MW 10) (J.11)
- Rice + pigeonpea (3:1) (MW 10) (ICPL 87)

Durg, Raigarh, Raipur

Sequence cropping

- Rice - Wheat/ chickpea (paired row)
- Rice - Lentil

Some other important practices

Bastar

- Finger millet (*mandiya*)
 - Early and Medium - HR 374, PES 400, RAU 8
 - Late - PR 202, PES 110, JNR-852, JNR 1001
- Kodo millet (*kadon*)
 - Early - GPUK 3
 - Medium & Late - IPS 147-1, RPS 136-1, PSC-1; JNK 364, D-73, Pali
- Little millet (*kutki*) - Gariyaband, PRC 3 and IGBKL 1,3 and 9
- Barnyard millet (*sawan*) - VL 29, VL 150
- Proso millet (*kossara*) - K1, Varada
- Foxtail millet (*gatka*) - Arjuna and SIA 326.
- Maize varieties have been recommended in the region:
 - Early: Kiran, Arun, Navjot, Pusa comp. II and Ageti-6
 - Medium: Ganga 5, Chandan Makka 3.

- Sorghum: CSH-5 and SPV 475 are recommended for South Bastar
- Blackgram: T 9, LBG 20, LBG 17, JU 2, PU 19 and Punt U 30
- Pigeonpea: Early: ICPL 151, ICPL 87; Medium duration: T 21.
- Horsegram (*Kulthi*): Among mid *kharif* season crops, *kulthi* is important due to its potential to withstand the adversities of sloppy eroded soils with very low fertility. Varieties for timely sown situation; VZM 1, PDM 1, K 42, VLG 1, For late sown situation: K 1
- Chickpea: JG 315, BF 9-3, JG 74, ICCV 10.
- Linseed: R 17, R 552, Kiran
- Greengram: RUM 1
- Field pea: Rachana, HPF-4

Durg, Raigarh, Raipur

- Under rainfed conditions, chickpea cv. JG-74 is most economical crop in place of lathyrus. Chickpea can also be grown as an *utera* crop in *Dorsa* and *Kanhar* (vertisols) soils.
- Cropping on Rice Bunds: Pigeonpea has been found to be most remunerative.

Farm implements/ tools

Raipur

- Dryland weeder

Alternate farming systems

Bastar

- Homestead Gardening (*bari situation*)
- Maize cultivation has got important place in homestead farming (kitchen gardening or *bari* cultivation) in Bastar region for having developed the taste by the people for utilizing green cobs as a source of food during scarcity period in rainy season, when other crops are still in field.
- Tuber crops: Tuber crops from an important component of diet of tribals. Different types of tubers are grown in *bari*.

Recommended varieties of tuber crops

Crops	Recommended improved varieties	Yield (q/ha)	Remarks
Cassava	H-119	190	Non branching
	BKC-1	171	Tolerant to mosaic
	H-165	165	Good table quality
Sweet potato	H-80/168	170	--
	H-85-16	157	Non Fibrous
	Sree Nandini	153	Extra early, 90 days
	H-85/168	259	Extra early, 90 days
Greater Yam (Nagar Kando)	DA-80	224	Good cooking quality
	DA-60	171	Good cooking quality
<i>Dioscorea alata</i> L. White Yam	Sree Latha	196	Good cooking quality
<i>Dioscorea rotundata</i> L. Colocassia (Arvi)	Bk.col.1	251	—
	White Gauriah	201	Excellent quality
	Bk.col.2	250	—

The vegetables and spices are cultivated mainly under *bari* situation (Homestead gardening).

Mixed Farming:

- Farmers in this region have low income and are seasonally under-employed. Introduction of dairy animals, goats, pigs, poultry, ducks, fish and other subsidiaries on their farm increases the opportunity for employment and adds to their income.
- A model of crop-livestock-fish farming was developed on 1.5 ha land holding. On this land holding best suited one for the tribal people, is model having 2 cows + 15 goats + 10 poultry birds + 10 ducks + fish (0.15 ha pond) along with crop cultivation (on 1.1 ha) with a cost returns of 1:2.

Livestock-horti-fish culture:

- Fish culture based on dairy washing, pig and poultry dung yielded 1.79 B/c ratio, Fish pond dyke farming by plantation of papaya and Karonda led to an additional income

Horticulture

- Mango: Dashehari, Langra, Alphonso and Sunderja have shown promising response. Cultivation of Amrapali is being recommended for high density planting.
- Guava: Allahabad safeda, L-49 and Red flesh are promising. L-49 is tolerant to wilt, adds biomass to soil and conserves moisture, and therefore recommended for commercial cultivation in the region.
- Papaya: Papaya cultivars, Coorg Honeydew, Pusa dwarf and Pusa nanha have shown promising response in Bastar Plateau zone.
- Tamarind: Tamarind is generally found growing as stray plantation or fencing material in and around Bastar. It is a very important crop of tribals and is main source of income during off-season.
- Cashew: Marhan (top upland) soils found over a wide range of Bastar plateau are generally degraded.
- Aquaculture: Highly water logged fields not suitable cultivation were found to be suitable for composite fish culture without any modification in the field. Stocking of 10,000 fingerlings and addition of 10 t of raw cow dung per hectare per year gave fish yield of 500 kg/ha
- Vegetable crops: Vegetables are an important component of farming under bari situation.
- Spices: Spices are grown extensively in Bastar. The important spice crops given below are ginger, turmeric, chillies and coriander. The recommended varieties of spices are -

Crops	Recommended improved varieties	Yield (q/ha)	Remarks
Onion	Nasik Red	265	Very popular among tribals, good keeping quality.
Ginger	Suprabha	239	Resistant to Ginger rot disease.
Turmeric	Poona	202	Fibreless.
	Shillong	155	Early type suitable for water logging condition.
	Roma	138	Popular among the tribals
	Surma	130	Popular among the tribals
Chilli	Pusa Sadabahar	15	Resistant to all diseases and very popular among the tribals.
	Jawahar 218	15	Tolerant to mosaic and leaf curl diseases.
	Pusa Jwala	14	Resistant to mosaic, long fruited type.
Coriander	UD-41	13	Small seeded.
	UD-21	10	Small seeded.
	CS-4	6	Suitable for Rainfed condition.

Mushroom Cultivation

It provides extra income during off-season from the wild edible mushroom and makes their diet rich in good quality protein. *Kodo*, Finger millet and soybean straws were found suitable for cultivation of oyster mushroom (Paddy straw was used as check). Species *Pleurotus florida* is recommended for cultivation.

Bio-fencing

Karonda has been recognized an ideal plant for bio-fencing and inter-plantation in cashew orchard based cropping system under waste land situations.

Animal Nutrition

Rice straw alone can be rendered a better basal feed for bullocks by adopting the urea ammonia technique (4 kg urea/65 l water/100 kg rice straw). The technique improves the palatability, protein content and dry matter intake.

Durg

- **Fodder/green biomass:** *Albizzia lebbeck*, *Leucaena leucocephala*, *Dalbergia sissoo*, *Azadirachta indica*, *Sesbania*, *Pongamia*
- **Fruit:** Ber, mango sapota, tamarind, fig
- **Medicinal and aromatic plants:** *Papaver somniferum*, *Rauwolfia*, *Liquorice*, Safed musli, Palma rosa
- **Vegetables:** Tomato, okra, bottle gourd, ridgegourd, amaranth, drumstick
- **Animal component:** Female cattle, male cattle, female buffaloes, male buffaloes

Horticulture

- Promising mango varieties recommended for different purposes are as follows:
- Langra – Banarasi, Desheri, Bombay Green (Table varieties)
- Rani Pasand (Sucking)
- Batasiya & Bitter gourd (Karela) (Pickle & *murabba*)

Agri-horticulture

- In newly planted mango orchards, intercropping with vegetables and legume crops (upto 5-7 years) found to be economical.
- Jharberi (*Ziziphus rotundifolia*) can easily be converted by budding into improved varieties.

Raigarh, Raipur

- Agri – 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 azadirach*, *Hardwickia binata*, *A.lebbeck*
- Fruit: Mango, ber, guava, tamarind, karonda
- Medicinal and aromatic plants: *Safed musli*, *Palma rosa*, *Withania somnifera*, *Papaver somniferum*, *Vetiveria zyzanoides*
- Vegetables: Brinjal, chilli, cowpea, okra, bottle gourd, round melon.
- Animal component: Female and male cattle, female buffaloes, goats

Horticulture

- Promising mango varieties recommended for different purposes are as follows:
- Langra – Banarasi, Desheri, Bombay Green (Table varieties)
- Rani Pasand (Sucking)
- Batasiya & Bitter gourd (Karela) (Pickle and *murabba*)
- In newly planted mango orchards, intercropping with vegetables and legume crops (upto 5-7 years) found to be economical.
- Jharberi (*Ziziphus rotundifolia*) can easily be converted by budding into improved varieties.

Contingent crop planning:

Bastar, Durg, Raigarh, Raipur

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

District	Region
Bilaspur Rajnandgaon Surguja	High runoff and High yield gap

Agro-ecological setting

Bilaspur

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

Rajnandgaon

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

Surguja

- **Climate:** Hot moist subhumid
- **Physiography:** Northern Chattisgarh
- **Soils:** Deep loamy to clayey red and yellow soils (Alfisols / Ustolls - 100%)
- **Annual rainfall:** 1406 mm
- **Potential evapotranspiration:** 1471 mm
- **Moisture availability period:** 150-180 days

Soil and water conservation

Bilaspur, Rajnandgaon

- Broad bed furrow
- Sowing across the slope
- Contour farming
- Contour farming
- Inter-plot water harvesting
- Raised bed and sunken system

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

Surguja

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

Crop management

Bilaspur, Rajnandgaon, Surguja

- **Rice Varieties:**
 - Uplands: Prasanna, Kalinga-III, Govinda, IR-50, JR-3-45, Vandana
 - Lowlands: JR-353, IR-36, Jaya, Kranthi, Mahamaya, and Karnal Basmati

Suitable rice varieties for light soils

Variety	Duration (days)	Description
Kalinga-III	85	Extra early maturing variety, tall, suitable for direct seeding. Due to early vigour, it can compete with weed population. It has long slender grain.
Vanaprabha	90	Extra early duration.
Aditya	90	Early duration, semi dwarf and blast resistant
Annada	105	Early duration, semi dwarf, drought tolerant and suitable for direct seeding and line sowing, It has short bold grain.
Tulsi	105	Early maturing, semi dwarf blast resistant with medium slender grain.
Poornima	105	Early duration, semi dwarf, suitable for bunded upland condition, long slender grains, good milling quality.
Rasi	110	Early duration, resistant to blast, suitable for bunded upland condition with medium slender grain.

Rice varieties suitable for places on toposequence

Soil type	Suitable Duration (days)	Varieties	Maturity (days)
Bhata	80-90	Vanaprabha	90
		Kalinga-3	85
		Aditya	90
Matasi	90-110	Tulsi	105
		Poornima	105
		Annada	105
		IR 64	110
Dorsa	110-130	IR 36	115
		Karnti	128
		Mahamaya	130
		Abhaya	125
Kanhar	130-140	Kranthi	128
		Mahamaya	130
Bahara	140-150	Safri 17	140-145
		Mahsuri	140-145
		Swarna	145-150

Varieties for special situations

- Gallmidge endemic areas - Mahamaya, Surekha, Phalguna, Ruchi and Abhay
- Blast endemic areas - Abhay, Aditya, Tulsi and Rasi
- Wild rice (*Karga*) - Shyamla
- Bahara land - Safri – 17, Mahsuri, Swarna
- Scented varieties - Madhuri, Pusa basmati
- Drought prone areas - Annada, Kalinga-III, Kranthi, Tulsi, Aditya, Poornima, Mahamaya
- The rice is grown from unbunded upland sloppy fields to leveled water logged bahara (low lying) fields
- Upland unbunded - Kalinga-III, Sattari, Poornima, Vandana
- Upland banded - IR-50, Annada, Poorva, Aditya

Seed rate: For broadcasting- 100 kg/ha; for drilling – 80 kg/ha

Planting pattern: 22.5 cm wide rows

- **Nutrient management**
 - 40kg N + 40 kg P₂O₅ /ha.
 - If rainfall is low, all P as basal and N in three splits viz., 50% at sowing, 25% at tillering and 25% at panicle initiation
 - If rainfall is good, 80 kg N in three splits viz., 25% at sowing, 50% at tillering and 25% at panicle initiation
- **Pest management**
 - Gundhi bug: Methyl Parathion 2% dust @ 20-25 kg/ha
 - Green hopper: Carbofuran 3 g @ 15 kg/ha and Monocrotophos 400 g a.i./ha.
 - Climbing cutworm: Endosulfan 600 g a.i /ha Malathion 0.05% in evening
 - Leaf blast: Hinosan 1 ml/l of water/ Bavistin 1 g/l of water
 - Bacterial leaf blight: Soak seeds in 0.025% water solution of Agrimycin + 0.03% wettable sulphur for 12 hours and then transferring the seeds to hot water at 52-54% OC for 30 minutes.
 - Khaira: 2 kg ZnSO₄ and 1 kg slacked lime 2 spray 10 days interval, immediately after the symptoms are noticed.
 - Weed control: Complete hand weeding early in the first 30 days after sowing with khurpi and wheel hoe Butachlor @ 2 l as pre emergence in broadcasted rice

Suitable cropping systems

Bilaspur, Rajnandgaon, Surguja

- Rice – Wheat/ chickpea (paired row)
- Rice – Lentil

Some other important practices

- Under rainfed conditions, chickpea cv. JG-74 is most economical crop in place of lathyrus. Chickpea can also be grown as an *utera* crop in *Dorsa* and *Kanhar* (vertisols) soils.
- Cropping on rice bunds: Pigeonpea has been found to be most remunerative
- Promising varieties of small millets in Northern hills
 - *Kutki* - RPM-83, RPM 60-1, Dindori-1
 - *Kodo* - GPK-4, JK-147, JK-41

- *Finger millet* - FM-2, KM-67, MK-68
- *Sawan* - ECC-6, ECC-7
- Intercropping of small millets with blackgram (2:2 rows) is more remunerative.
 - Maize: Under *bari* During lean months of August/ September. Vijay composite, Chandan Safed-2 and Chandan-3. Intercropping of maize with pigeonpea has been found to be quite remunerative.
 - Horsegram (*Kulthi*): It is an important pulse crop of tribals and is grown on hill slopes as a mid-season crop in August-September. K-42 and Birsa *kulthi*. The early sowing and use of small dose of nutrients
 - Niger: It is grown almost in a situation similar to that of horsegram. The recommended improved varieties are Ootacamond, N-35 and IGP-76.
 - Rapeseed is a principal crop in maize-toria sequence under *bari* situation. The suitable varieties of toria are T-9 and PT 303.
- Blackgram - T-9, Pant U-30, PDU-1
- Groundnut - JL-24, J-11, ICGS-82
- Soybean - Gaurav, Durga
- Pigeonpea - ICPL-267, UPAS-120 and TAT-10 Mainpat (Local)
- Chickpea - JG-74, JG-315, Phule G-5
- Field pea - Khaparkheda, Rachana, JP-789
- Linseed - R-552, Kiran
- In *kharif*, pigeonpea, soybean and groundnut are recommended as intercrops while in *rabi*, mustard, peas and linseed were grown.
- For reclamation of acidic soils add lime @ 2 t/ha or Kimberlite @ 5 t/ha.

Farm implements/ tools

Bilaspur

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

Surguja

- Dryland weeder

Alternate farming systems

Bilaspur

- Agri – horti system: Mango + pea/ berseem (green fodder)/ wheat/ chickpea/ soybean
- Silvi – pastoral system: Teak + sudan grass
- Fodder/ green biomass: *Leucaena leucocephala*, *Albizzia amara*, *Dichrostachys cineria*, *Melia azadirach*,

Hardwickia binata, *A.lebbeck*

- Fruit: Mango, ber, guava, tamarind, karonda
- Medicinal and aromatic plants: *Safed musli*, *Palma rosa*, *Withania somnifera*, *Papaver somniferum*, *Vetiveria zyzanoides*
- Vegetables: Brinjal, chilli, cowpea, okra, bottle gourd, round melon.
- Animal component: Female and male cattle, female buffaloes, goats

Horticulture:

- Promising mango varieties recommended for different purposes are as follows:
- Langra – Banarasi, Desheri, Bombay Green (Table varieties)
- Rani Pasand (Sucking)
- Batasiya & Bitter gourd (Karela) (Pickle & *murabba*)
- In newly planted mango orchards, intercropping with vegetables and legume crops (upto 5-7 years) found to be economical.
- Jharberi (*Ziziphus rotundifolia*) can easily be converted by budding into improved varieties.
- Lucknow-49 is recommended for guava cultivation.
- In ginger, addition of NPK @ 150:50:100 kg/ha gave highest yield.
- In turmeric, NPK application @ 135:90:90 kg/ha was found to be the best.
- Agri-horticulture
 - Inter cropping of ginger, okra, cowpea, groundnut, soybean, blackgram and pigeonpea was are recommended in mango orchard plantation.
- Silviculture
 - The multipurpose tree species with fast growth rate are Khamhar (*Gmelina arborea*), Shisham (*Dalbergia sissoo*), Poplar (*Populus deltoides*), Bakain, Cassuarina spp., Archasia spp. *Cassia siamea* and *Acacia* spp.
 - Poplar (*Populus deltoides*), Shisham (*Dalbergia sissoo*), Shisham (*Dalbergia sissoo*), Shisham (*Dalbergia sissoo*), Khamhar (*Gmelina arborea*) and Siris (*Albeizia lebbeck*) are recommended for silviculture.

Rajanandagaon

- Fodder/green biomass: *Albizia lebbeck*, *Subabul*, *Dalbergia sissoo*, *Azadirachta indica*, *Sesbania*, *Pongamia*
- Fruit: Ber, mango sapota, tamarind, Fig
- Medicinal and aromatic plants: *Papaver somniferum*, *Rauvolfia*, *Liquorice*, *Safed musli*, *Palma rosa*
- Vegetables: Tomato, okra, bottle gourd, ridge gourd, amaranthus, drumstick
- Animal component: Female and male cattle, female and male buffaloes

Horticulture

- Promising mango varieties recommended for different purposes are as follows:
- Langra – Banarasi, Desheri, Bombay Green (Table varieties)
- Rani Pasand (Sucking)
- Batasiya & Bitter gourd (Karela) (Pickle & *murabba*)
- In newly planted mango orchards, intercropping with vegetables and legume crops (upto 5-7 years) found to be economical.
- Jharberi (*Ziziphus rotundifolia*) can easily be converted by budding into improved varieties.

Surguja

- Agri – hortisystem: Mango + Pea/ Berseem (green fodder)/ Wheat/ Chickpea/ Soybean
- Silvi – pastoral system: Teak + Sudan grass
- Fodder/ green biomass: *Leucaena leucocephala*, *Albizia amara*, *Dichrostachys cinerea*, *Melia azadirach*, *Hardwickia binata*, *Albizia lebbeck*
- Fruit: Mango, Ber, Guava, Tamarind, Karonda
- Medicinal and Aromatic Plants: *Safed musli*, *Palma rosa*, *Withania somnifera*, *Papaver somniferum*, *Vetiveria zizanioides*
- Vegetables: Brinjal, Chilli, Cowpea, Okra, Bottle gourd, Round melon
- Animal component: Female cattle, Male cattle, Female buffaloes, Goats

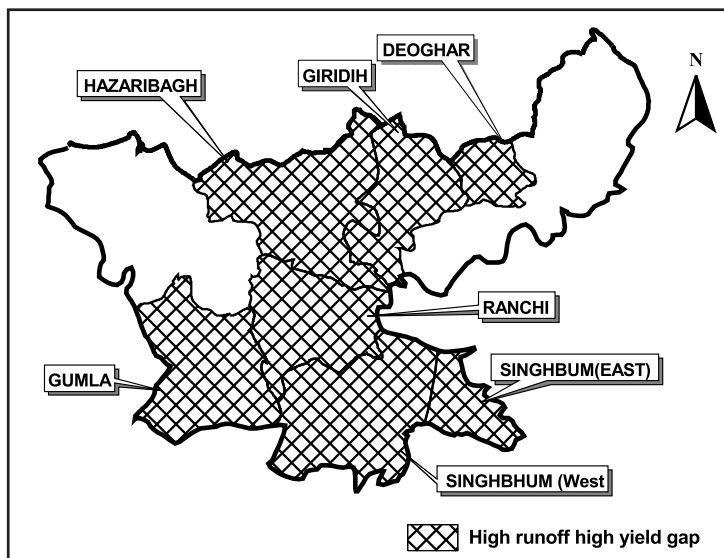
Contingent planning

Bilaspur, Rajnandgaon, Surguja

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

JHARKHAND

In Jarkhand there are seven districts viz. Ranchi, Hazaribagh, Giridih, Gumla, Deoghar (Devghar), Singbhum (East), Singbhum (West) under high runoff and high yield gap region.



The setting and recommendations follow:

District	Region
Deoghar	High runoff and High yield gap
Giridih	
Gumla	
Hazaribagh	
Ranchi	
Singbhum (East)	
Singbhum (West)	

Agro-ecological setting

Deoghar

- **Climate:** Hot dry sub humid
- **Physiography:** Chotanagpur plateau (Eastern plateau)
- **Soils:** Moderate deep to deep loamy to clayey red and lateritic soils (Alfisols/ Ustolls – 100%)
- **Annual rainfall:** 1242 mm
- **Potential evapotranspiration:** 1501 mm
- **Moisture availability period:** 150-180 days

Giridih

- **Climate:** Hot dry sub humid
- **Physiography:** Chotanagpur plateau (Eastern plateau)
- **Soils:** Moderate deep to deep loamy to clayey red and lateritic soils (Alfisols/ Ustolls – 100%)

- **Annual rainfall:** 1145 mm
- **Potential evapotranspiration:** 1499 mm
- **Moisture availability period:** 150-180 days

Gumla

- **Climate:** Hot moist/ dry sub humid
- **Physiography:** Chattisgarh / Mahanadi basin
- **Soils:** Deep loamy to clayey red and yellow soils (Alfisols/ Ustolls – 100%)
- **Annual rainfall:** 1510 mm
- **Potential evapotranspiration:** 1413 mm
- **Moisture availability period:** 150-180 days

Hazaribagh

- **Climate:** Hot moist/ dry sub humid
- **Physiography:** Chattisgarh / Mahanadi basin
- **Soils:** Deep loamy to clayey red and yellow soils (Ustolls – 100%)
- **Annual rainfall:** 1319 mm
- **Potential evapotranspiration:** 1365 mm
- **Moisture availability period:** 150-180 days

Ranchi

- **Climate:** Hot moist/ dry sub humid
- **Physiography:** Chotanagpur plateau (Eastern plateau)
- **Soils:** Deep loamy to clayey red and yellow soils, Moderate deep to deep loamy to clayey red and lateritic soils (Ustolls – 100%)
- **Annual rainfall:** 1462 mm
- **Potential evapotranspiration:** 1304 mm
- **Moisture availability period:** 150-180 days

Singbhum (East)

- **Climate:** Hot dry sub humid
- **Physiography:** Chotanagpur plateau (Eastern plateau)
- **Soils:** Ustolls – 100% iron rich
- **Annual rainfall:** 1392 mm
- **Potential evapotranspiration:** 1449 mm
- **Moisture availability period:** 150-180 days

Singbhum (West)

- **Climate:** Hot dry sub humid
- **Physiography:** Chotanagpur plateau (Eastern plateau)

- **Soils:** Ustalf/ Ustolls – 100%
- **Annual rainfall:** 1314 mm
- **Potential evapotranspiration:** 1304 mm
- **Moisture availability period:** 150-180 days

Soil and water conservation

Deoghar, Giridih, Gumla, Hazaribagh, Ranchi, Singhum (East), Singhum (West)

- Sowing across the slope
- Contour farming
- The fields must be bunded to conserve soil moisture in uplands
- Intercepts 1 m wide x 0.5 m deep at 20 m interval across the slope

Crop management

Deoghar, Giridih, Hazaribagh, Ranchi, Singhum (East), Singhum (West)

- **Varieties:** Brown Gora 23 –19, Vandana, Kalinga-III, Birsa Dhan-101, Birsa Dhan-102, Birsa Dhan-103, Anjali
- **Seed rate:** 100 kg/ha
- **Planting pattern:** 20 cm inter row and thick intra sowing
- **Nutrient management**
 - HYVs: 50 kg N + 30 kg P₂O₅ + 20 kg K₂O/ha N in 3 splits (10 Basal + 20 at 20 days after germination + 20 at 35 days after germination)
 - Local: 30 kg N + 20 kg P₂O₅ + 20 kg K₂O /ha.
 - Apply N in three splits at 20, 35, 45 days after sowing. Give top dressing post-heavy rains. Basal application helps fighting drought. Apply Phosphorus in deficient soils after incubating Single Super Phosphate with FYM (1:2 ratio on dry weight basis) for 72 hrs in shade.
- **Pest management**
 - Off- season tillage and use of wide blade harrow
 - 1.5 kg Machete as pre-emergence spray + 2.7 kg a.i. /ha Stam F – 34 as post emergence spray for chemical weed control.
 - Gundhi bug: Spray Endosulphan @ 2.5 ml/l
 - Blast: Spray Hinosan (0.1%), Resistant Variety (Vandana)
 - Brown spot: Dithame M-45(2.58/l), Tilt 1 ml/l of water
 - Sheath rot: Mechanically separated seed (using 20% common salt solution)

Gumla

- **Varieties:** Birsa Dhan – 202, Birsa Dhan 101, Vandana, Anjali
- **Seed rate:** 100 kg/ha
- **Planting pattern:** 20 cm inter row and thick intra row sowing
- **Nutrient management**
 - HYVs: 50 kg N + 30 kg P₂O₅ + 20 kg K₂O/ha N in 3 splits (10 Basal + 20 at 20 days after germination + 20 at 35 days after germination)

- Local: 30 kg N + 20 kg P₂O₅ + 20 kg K₂O /ha.
- Apply N in three splits at 20, 35, 45 days after sowing. Place 5 cm below the seed. Give top dressing post-heavy rains. Basal application helps fighting drought. Apply Phosphorus in deficient soils after incubating Single Super Phosphate with FYM (1:2 ratio on dry weight basis) for 72 hrs in shade.
- **Pest management**
 - Off- season tillage and use of wide blade harrow
 - 1.5 kg Machete as pre-emergence spray + 2.7 kg a.i. /ha Stam F – 34 as post emergence spray for chemical weed control
 - Gundhi bug: Spray Endosulphan @ 2.5 ml/l
 - Blast: Spray Hinosan (0.1%), Resistant Variety (Vandana)
 - Brown spot: Balanced fertilizers, tolerant varieties such as Anjali and spray Tilt 1 ml/water

Suitable cropping systems

Deogarh, Giridih, Hazaribagh and parts of Ranchi

- **Intercropping**
 - Rice + pigeonpea (4:1 row ratio)
 - Rice + groundnut (4:2 row ratio)
 - Maize + pigeonpea + cowpea (one row of cowpea in between two rows of maize and pigeonpea)
 - Pigeonpea + groundnut/ blackgram/ cowpea/ sesame
 - Maize + cowpea/ pigeonpea
- **Sequence cropping:**
 - Rice – linseed

Gumla

- **Intercropping:**
 - Pigeonpea + sesame
 - Pigeonpea + maize
 - Rice (Brown Gora) + pigeonpea (4:1), pigeonpea 75 cm apart
 - Rice (Vandana) + pigeonpea (4:1), pigeonpea 75 cm apart
 - Maize + pigeonpea + cowpea (one row of cowpea in between two rows of maize and pigeonpea)
 - Pigeonpea + groundnut
 - Pigeonpea + blackgram
 - Pigeonpea + cowpea
 - Maize + cowpea/ pigeonpea
- **Sequence cropping:**
 - Rice – linseed drought prone shallow - lowland
 - Rice – chickpea
 - Rice – toria

Some other important practices

Deoghar, Giridih, Hazaribagh and parts of Ranchi

- Wheat: C-306, K-8027
- Groundnut: TG-22, Birsa Bold, JL-24, GG-2

- Mustard: Varuna (extensively in *Rabi*), Pusa Bold
- Niger: N-5
- Safflower: A-300
- Pigeonpea: Birsa Arhar-1, BR-65, ICPL-87
- Blackgram: Pant U-19, T-9
- Horsegram: Birsa Kulthi-1
- Rice:
 - Low land – Sita, Swarna
 - Medium Land - IR-36, Kanak, Mahsoori, Jaishree Birsa Dhan –202, Hazaridhan, Sadabahar, IR-64
- Maize - Composite (Suwan-1)
- Sesame - Kanke White
- Chickpea - ST-4 (Shallow low land with supportive soil moisture)
- Soil application of Boron @ 2.5 kg/ha in groundnut gives higher yield
- Boron application @1.0 kg/ha in pigeonpea gives higher yield.
- Apply 45 kg urea at sowing, 22 kg urea after 25 days and for other varieties apply 37 kg urea + 250 kg single super phosphate + 33 kg Murate of potash as basal and apply 37 kg of urea each time at 20 and 45 days after sowing.
- In rice, apply 21 kg urea as basal in furrow, 42 kg urea 20 days after germination and 42 kg urea 35 days after germination.

Gumla

Suggestions to fight drought condition

- In uplands, crops of low water requirement with their drought tolerant varieties should be grown in place of rice crop (drought tolerant varieties are available). If monsoon delays, rice variety Sneha can be grown successfully.
- There are certain crops (niger, horsegram etc.), which may be grown successfully when monsoon is delayed.
- There should be of water harvesting facilities to meet the requirement of life saving irrigation during the drought period. There must be small ponds in lowland, open wells in lowland, check dam in series at 20 m interval on Nallah (creeks) for not only life saving but also for sequence cropping.

Singbhum (East) and Singbhum (West)

Upland condition

- Replacement of long duration local varieties of rice by introduction of short duration (100 days) improved variety (Birsa 101) with fertilizer dose $N_{50} P_{30} K_{20}$ kg/ha.
- Pigeonpea (BR-65) + groundnut (BG-3) intercropping systems in 2:6 and 1:2 row ratio may be followed in the zone in order to increase the production per unit area per unit time and to reduce the risk of uncertainty due to vagaries of nature. In general, intercropping systems should be preferred over pure crops.
- Replacement of low yielding local varieties of maize by Suwan composite variety which is high yielding. The recommended dose of fertilizer for maize is $N_{100} P_{60} K_{40}$ kg/ha.
- Cultivation of improved variety of Niger (N-5 and Ootkamund)

- Cultivation of improved varieties (TG-24, BG-3 and AK-12-24) of groundnut is more profitable as compared to other existing crops. Groundnut is new introduction in the zone.
- Furrow application of lime @ 3 q/ha/yr for lime responsive crops (groundnut and pulse crops).

Medium land situation

- Rice varieties : IR-36, Birsa Dhan-202, Hazaridhan, IR 64, Lalat, Swarna
- For the cultivation of linseed as paira crop, 30 kg seed and apply 40 kg N/ha
- In general, double cropping of rice-linseed should be preferred over monocropping provided moisture is adequate in the *rabi* season.

Farm implements/ tools

Deogarh, Giridih, Gumla, Hazaribagh, Ranchi, Singhum (East), Singhum (West)

- Bullock drawn 2 row seed cum fertilizer drill: For seeding dryland crops and fertilizer (Rs.1500/- per unit) in well pulverized soils.
- Bullock drawn ridger (single row): For seeding when 8-10 cm top soil gets dry. But soil moisture is available below this depth. Seed metered by hand (Rs.100/- per unit)

Alternate farming systems

Deogarh, Giridih, Hazaribagh, Ranchi, Singhum (East), Singhum (West)

- Denuded eroded, highly sloppy and shallow lands: social forestry, silvipasture
- Deeper and light textured uplands
 - Crops: Groundnut, soybean, finger millet, maize, sorghum, pigeonpea, blackgram, greengram, sweet potato, sesame, niger, horsegram
- Uplands :-
 - Horticulture: Mango, litchi, guava, lemon, custard apple, jack fruit.
 - Fodder/ green biomass: Social forestry, farm forestry and establishment of pasture crops in denuded, eroded, highly sloppy and shallow lands.
- *Subabul*, *B.monosperma*, *A. indica*, *D.sissoo*, *A.procera*, *Pongamia pinnata*, *B. variegata*
- Fruit: Mango, phalsa, jamun, ber, fig, bael
- Medicinal and aromatic plants: *Ravoulfia serpentina*, *Palma rosa*, *Vetiveria zyzanoides*, *Papaver somniferum*
- Vegetables: Bottle gourd, ridge gourd, bitter gourd, water melon, cowpea, brinjal, okra, *Papaver somniferum*, tomato, cauliflower, coriander leaf.
- Animal component: Female cattle, male cattle, female buffaloes, male buffaloes, sheep, poultry, goat, pigs. It is not alternatives. It needs only to introduce improved breed with availability of fodder and irrigation.

Alternate farming systems

Deogarh, Giridih, Hazaribagh, Ranchi, Singhum (East), Singhum (West)

Non arable lands

- Tree farming (Sal, Teak, *Shorea robusta*)
- Silvipastoral system (Shisham/ *Leucaena*/ gamhar + Stylo/ *Cenchrus*/ mixture)
- Arable wastelands

- Agri-horticulture: Fruit crops (Mango/ citrus/ sapota/ pomegranate/ custardapple/ litchi/ Jack fruit, Jumun) + Field crops (Pulses/ oil seeds)
- Alley cropping: *Leucaena* + turmeric/ginger

Low fertility, unbunded uplands

- Transplantation of finger millet, niger (Birsa niger, N5)
- Cowpea – Niger

Uplands

Mono-cropping

- Upland, finger millet, pulses, oil seeds and *kharif* vegetables like, cauliflower, capsicum, lady finger and French bean etc.

Sequence cropping

- Rice (Brown gora 23 –19), Birsa dhan 101, and Vandana Niger and Toria

Medium lands

- Rice (IR 36, IR 64, Pant 4) linseed (T 397)/ Gram (BR 17, BR 77 and C 235)/ Safflower (A 300, 59-2-1)/ lentil (BR 25) Rai (BR 40) and Niger (N5)
- Relay cropping
- Rice (Ladut, Swarna, IR 36 etc)- Lathers (local)

Lowland

Sequence cropping

- Rice (Tulegi, Pusa-44)- Late sown wheat (HPI 744)/ tomato without irrigation

Gumla

Horticulture: The following species of citrus fruit crops have been recommended for the region.

- Santra - Nagpur and Darjeeling
- Sweet Orange - Mosambi and Norallensia
- Grape fruit - Saharanpur
- Lime and lemon - Limepati Ever Bearer
- Sweet Lime - Sarbati
- Ummela - Red fleshed
- Amla - Chakaiya
- Ber - Gola and Karaka
- Custard Apple - Pond apple and Sangaready
- Guava - Allahabad Safeda and Lucknow-49
- Pomegranate - Kabili and Jodhpur

Contingent crop planning

Deoghar, Giridih, Gumla, Hazaribagh, Ranchi, Singbhum (East), Singbhum (West)

Normal sowing period (15th to 30th June)

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

- Rice: Brown Gora 23-19, Vandana, Birsadhan 101, Anjali, Sneha, Kalinga-III

- Finger millet: A. 404, PR. 202, IE. 723 (direct seeding as well as nursery sowing of all the 3 varieties)
- Maize: Ganga Safed. 2, Ganga. 5. Suwan. 1
- Sorghum: CSH. 5 and CSH. 6
- Groundnut: AK 12-24, Birsa Groundnut. 1, BG. 1, BG.2, Birsa bold
- Soybean: Birsa Soybean- 1, Bragg
- Pigeonpea: BR. 103, 65, Upas 120
- Greengram: Sunaina
- Blackgram: T. 9
- Intercrop: Pigeonpea + rice, pigeonpea + maize, pigeonpea + groundnut, pigeonpea + 2 rows finger millet, pigeonpea + blackgram/ greengram, (two row) pigeonpea + 2 rows soybean.

If the onset is delayed but is expected within a week or 10 days of normal onset date – Dry seeding of all the rice and groundnut varieties mentioned above in mid June

Delayed sowing period (1 – 7 July)

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

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

- Transplanting of finger millet (all varieties) but spacing to be reduced from 20 x 15 cm to 20 x 10 cm
- Greengram: Sunaina
- Blackgram: T-9
- Sesame: Kanke white (normal sowing time), Krishna
- Sweet potato: Cross 4 and Local (normal sowing time)

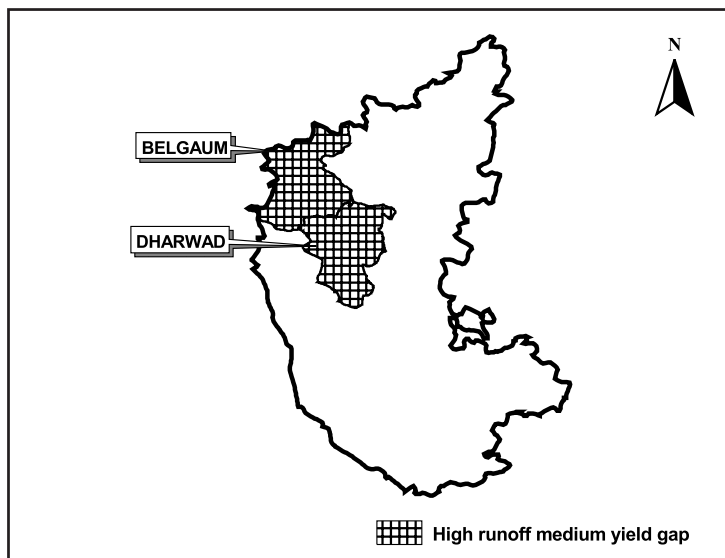
Beyond July it is too late for general crops. However, if seedlings are available, transplanting of finger millet could be resorted to in early August. Niger (N.5) and horsegram (BR. 10 Madhu) are the natural choice for August seeding.

General precautions in case of delayed sowing

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

KARNATAKA

In Karnataka there are two districts viz. Belgaum and Dharwad under high runoff and medium yield gap region.



The setting and recommendations follow:

District	Region
Belgaum Dharwad	High runoff and Medium yield gap

Agro-ecological setting

Belgaum

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

Dharwad

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

Soil and water conservation

Dharwad

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

Belgaum

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

Crop management:

Belgaum, Dharwad

- Locally available upland rice varieties may be adopted.

Farm implements/ tools

Dharwad

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

Belgaum

- Ferti - cum - seed drill

Alternate farming systems

Belgaum

- Agave (*Agave sisolana* with 10, 000 plants /ha) intercropped with *subabul*. Cutting of agave leaves once in a year for fibre extraction after retaining top ten leaves

Silviculture

- Shallow black soils: *Casuarina*, *Dalbergia sissoo*, *Hardwickia binata*, *Acacia nilotica*, *Prosopis cineraria*
- Marginal land: *Dalbergia sissoo*, neem, *Acacia nilotica*, *Subabul*
 - Alley cropping: *Subabul*/ *cassuarina* + *Kharif* crops

- Agro horti system: Ber (umran) + curry leaf
- Vegetable – curry leaf
- Ber (umran) – safflower + chickpea
- Ber / custard apple/ pomegranate/ amla + *kharif* (spreading) crops
- Horticulture: Mango plants in leveled portion of zing conservation terrace
- Fodder/ green biomass: *Dalbergia sissoo*, *Glyricidia*, *Albizzia lebbeck*, *Hardwickia binata*, *Cassia siamia*, *Azadirachta indica*
- Fruit: Mango, pomegranate, sapota, ber, jamun, and tamarind
- Medicinal / Aromatic plants: *Cassia angustifolia*, *Catharanthus roseus*, *Palma rosa*, *Vetiveria zizanioides*, *Rose*, *Geranium*
- Vegetables: Onion, brinjal, chillies, cowpea, cucumber, clusterbean, drumstick
- Animal Component: Male/ female cattle, female buffaloes, sheep, goat, poultry

Contingent crop planning:

Belgaum, Dharwad

Normal onset of monsoon favourable for *kharif* crops

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

- In *rabi* areas, i.e., medium deep black soils, sow greengram, blackgram, cucumber as a first crop to be followed by *rabi* sorghum / sunflower/ chickpea/ safflower/ wheat.
- When the land is kept fallow (deep black soils) for *rabi* crops, have compartment bunds having 1 per cent slope, scooping where the land slope is 1 to 2 per cent, ridges and furrows or tied ridges for better soil and moisture conservation. Take up harrowings after each rain, which helps, in controlling weeds and conserving soil moisture.
- Sow sunhemp as green manuring crop in medium to deep black soils prior to *rabi* crops.

Normal onset of monsoon but dry spells soon after germination:

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

No normal rains in June but onset of rains in July:

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

Normal rains in July/ August:

- Complete sowing dryland cotton before the middle of August. Grow *Herbaceum* cotton in place of *Hirsutum*. 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 times the normal seed rate relatively at depth without applying chemical fertilizers. Fertilizers may be applied at appropriate growth stage having optimum moisture condition.

Sowing in October:

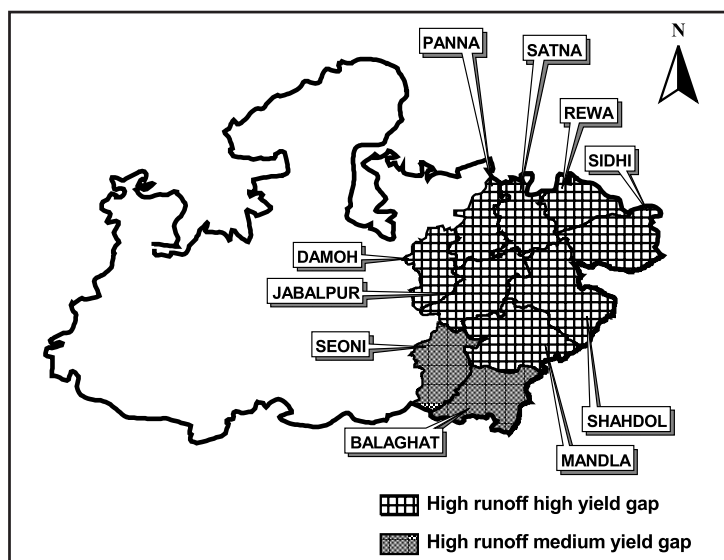
- Continue the sowing of *rabi* sorghum till October 15th with 50 per cent recommended level of fertilizer.
- Follow mixed cropping of *rabi* sorghum + chickpea in 2:1 row proportion.
- Sow *rabi* sorghum and chickpea as mixed crops (random mixing).
- Increase the area under safflower.
- Sow chickpea 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.

MADHYA PRADESH

In Madhya Pradesh there are two districts viz. Balghat and Seoni under high runoff and medium yield gap region and eight districts viz. Damoh, Panna, Rewa, Sidhi, Satna, Jabalpur, Mandla and Shahdol under high runoff and high yield gap region.



The setting and recommendations follow:

District	Region
Balaghat Seoni	High runoff and Medium yield gap

Agro-ecological setting

Balaghat

- **Climate:** Hot moist sub humid
- **Physiography:** Satpura range (Central highlands).
- **Soils:** Shallow to deep loamy to clayey mixed red and black soils (Vertic Inceptisols – 85%; Udupts/ Alfisols – 30%; Aridisols – 20%)
- **Annual rainfall:** 1474 mm
- **Potential evapotranspiration:** 1419 mm
- **Moisture availability period:** 180-210 days

Seoni

- **Climate:** Hot moist sub humid
- **Physiography:** Satpura range (Central highlands).
- **Soils:** Shallow to deep loamy to clayey mixed red and black soils (Vertic Inceptisols- 85%; Vertisols – 15%)
- **Annual rainfall:** 1447 mm

- **Potential evapotranspiration:** 1421 mm
- **Moisture availability period:** 180-210 days

Soil and water conservation

Balaghat

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

Seoni

- Straighten the gullied portion in the farmers' fields through earth moving machinery to reduce the length of gully allowing safe passage for the runoff water. It brings additional area under cultivation through reclamation process.
- Construct 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 side to increase life of water storage bodies.
- Construct water harvesting tank to retain the excess runoff from the watershed area to use stored water for irrigation purpose.
- Silpaulin (plastic material) of 90 – 120 gsm has been found effective lining material for farm ponds used for water harvesting purposes.
- Use vegetative barriers to strengthen the mechanical bunds at suitable vertical intervals in order to reduce runoff in associated soil losses from the cultivated fields.
- Mould board plough for deep tillage to increase 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 runoff 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 prove most effective in controlling soil erosion and nutrient losses on soils having slope up to 2 per cent.
- Off-season shallow tillage is important not only in controlling the weeds, but also in helping entry of rainwater.
- Develop a sort of terracing to break the continuity of undulating slope to reduce the changes of degrading cultivated fields in to gullied one.
- Provide *in situ* soil mulch by operating bullock drawn dora to fill up the cracks, to conserve the soil moisture and to achieve weed control. Straw as mulch @ 4-5 t/ha in between the rows of crop plants to minimize evaporative losses, moisture conservation and to increase moisture efficiency in *rabi* crops.

Crop management

Balaghat, Seoni

- **Varieties:**
 - Uplands: Prasanna, Kalinga-III, Govinda, IR-50, JR-3-45, Vandana
 - Lowlands: JR-353, IR-36, Jaya, Kranthi, Mahamaya, and Karnal Basmati

Suitable rice varieties for light soils

Variety	Duration (days)	Description
Kalinga-III	85	Extra early maturing variety, tall, suitable for direct seeding. Due to early vigour, it can compete with weed population. It has long slender grain
Vanaprabha	90	Early duration, tall and blast tolerant
Aditya	90	Early duration, semi dwarf and blast resistant
Annada	105	Early duration, semi dwarf, drought tolerant and suitable for direct seeding and line sowing, It has short bold grain
Tulsi	105	Early maturing, semi dwarf blast resistant with medium slender grain
Poornima	105	Early duration, semi dwarf, suitable for banded upland condition, long slender grains, good milling quality
Rasi	110	Early duration, resistant to blast, suitable for banded upland condition with medium slender grain

Rice varieties suitable for drought-prone rainfed area

Soil type	Suitable Duration (days)	Varieties	Maturity (days)
Bhata	80-90	Vanaprabha Kalinga-III Aditya	85
Matasi	90-110	Tulsi Poornima Annada IR 64	105 105 105 110
Dorsa	110-130	IR 36 Karnti Mahamaya Abhaya	115 128 130 125
Kanhar	130-140	Kranthi Mahamaya	128 130
Bahara	140-150	Safri 17 Mahsuri Swarna	140-145 140-145 145-150

Suitable rice varieties for special situations

- Gallmidge endemic areas - Mahamaya, Surekha, Phalguna, Ruchi and Abhay.
- Blast endemic areas - Abhay, Aditya, Tulsi and Rasi
- Wild rice (*Karga*) - Shyamla
- Bahara land - Safri – 17, Mahsuri, Swarna
- Scented varieties - Madhuri, Pusa basmati
- Drought prone areas - Annada, Kalinga-III, Kranthi, Tulsi, Aditya, Poornima, Mahamaya, Vandana.
- **Seed rate:** For broadcasting- 100 kg/ha; for drilling – 80 kg/ha
- **Planting pattern:** 22.5 cm rows
- **Nutrient management**
 - 40 kg N + 40 kg P₂O₅ /ha.
 - If rainfall is low, all P₂O₅ as basal and N in three splits viz., 50% at sowing, 25% at tillering and 25% at panicle initiation

- If rainfall is good, 80 kg N in three splits viz., 25% at sowing, 50% at tillering and 25% at panicle initiation
- **Pest management**
 - Gundhi bug: Methyl Parathion 2% dust @ 20-25 kg/ha
 - Green hopper: Carbofuran 3 g@ 15 kg/ha, and Monocrotophos 400 g a.i./ha.
 - Climbing cutworm: Endosulfan 600 g a.i /ha Malathion 0.055 at evening
 - Leaf blast: Hinosan 1 ml/l of water/ Bavistin 1 g/l of water
 - Bacterial leaf blight: Soak seeds in 0.025% water solution of Agromycin + 0.03% Wettable Sulphur for 12 hours and then transferring the seeds to hot water at 52-54°C for 30 minutes.
 - Khaira: 2 kg ZnSO₄ and 1 kg slacked lime 2 spray 10 days interval, immediately after the symptoms are noticed.
 - Weed control: Complete hand weeding early in the first 30 days after sowing with khurpi and wheel hoe Butachlor @ 2 l as pre emergence in broadcasted rice

Suitable cropping systems

Balaghat, Seoni

- Rice – wheat/ chickpea (paired row)
- Rice – lentil

Some other important practices

- Under rainfed conditions, chickpea cv. JG-74 is most economical crop in place of lathyrus. Chickpea can also be grown as an *utera* crop in *Dorsa* and *Kanhar* (vertisols) soils.
- Cropping on Rice Bunds: Pigeonpea has been found to be most remunerative.

Farm implements/ tools

Seoni, Balaghat

- Suitable implements for seedbed preparations:
 - Meston Plough
 - Iron Bakhar
- Suitable implements for sowing operations:
 - Mostly the sowing operation is done using seeds drills
 - For planting intercrops, intercrop seed drill is available
 - Mahakal Dufan
 - Mahakal Tifan and
 - Sarta attachment for intercropping
- Suitable implements/ tools for interculture operations:
 - Hand dora (small blade harrow)
 - Bullock drawn dora (small blade harrow with wooden beam)
 - Indore ridger

Alternate farming systems

Balaghat

- Alley cropping – *Subabul* (4 m interval) - + groundnut/sesame/cowpea (grain)

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

Seoni

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

Contingent planning

Balaghat

Cropping systems under drylands

- **June**
 - **Sole crop**
 - Sorghum (CSH 5, JS 1041)
 - Greengram (K 850)
 - Blackgram (JU 2, PDU 4)
 - Groundnut (Jawahar Jyoti, M 13)
 - **Inter crop**
 - Sorghum + pigeonpea (2:1)
 - Soybean + pigeonpea (2:1)
- **July**
 - **Sole crop**
 - Rice (IR 50, JR 345)
 - Kodo (JK 155, JK 76, JK 136)
 - Sorghum (CSH 5)
 - Pigeonpea (NPWR –15, JA4, Asha)

- Groundnut (Jyoti, M 12, Exotic 1-1)

• **August**

- Castor (Aruna)
- Pigeonpea (No.148)

• **October**

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

Seoni

June

- Sole crop
 - Sorghum (CSH 5, JS 1041)
 - Greengram (K 850)
 - Blackgram (JU 2, PDU 4)
 - Groundnut (Jawahar Jyoti, M 13)
- Inter crop
 - Sorghum + pigeonpea (4: 2)
 - Soybean + pigeonpea (4: 2)

July

- Sole crop
 - Rice (IR 50, JR 345)
 - Kodo (JK 155, JK 76, JK 136)
 - Sorghum (CSH 5)
 - Pigeonpea (NPWR -15, JA4, Asha)
 - Groundnut (Jyoti, M 12, Exotic 1-1)
- Inter crop
 - Sorghum + pigeonpea (4: 2)
 - Soybean + pigeonpea (4: 2)

August

- Castor (Aruna)
- Pigeonpea (No.148)

October

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

District	Region
Damoh Jabalpur Mandla Panna Rewa Satna Shahdol Sidhi	High runoff and High yield gap

Agro-ecological setting

Damoh

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

Jabalpur

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

Mandla

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

Panna

- **Climate:** Hot dry sub humid
- **Physiography:** Baghel khand plateau (Central highlands).
- **Soils:** Deep loamy to clayey mixed red and black soils (Vertic Inceptisols – 100%)

- **Annual rainfall:** 1186 mm
- **Potential evapotranspiration:** 1436 mm
- **Moisture availability period:** 150-180 days

Rewa

- **Climate:** Hot dry sub humid
- **Physiography :** Baghel khand plateau (Central highlands).
- **Soils:** Deep loamy to clayey mixed red and black soils (Vertic Inceptisols – 60%; Inceptisols – 25%; Alfisols/ Ustolls – 15%)
- **Annual rainfall:** 1079 mm
- **Potential evapotranspiration:** 1453 mm
- **Moisture availability period:** 150-180 days

Satna

- **Climate:** Hot dry sub humid
- **Physiography:** Baghel khand plateau (Central highlands).
- **Soils:** Deep loamy to clayey mixed red and black soils (Vertic Inceptisols – 100%)
- **Annual rainfall:** 1138 mm
- **Potential evapotranspiration:** 1452 mm
- **Moisture availability period:** 150-180 days

Shahdol

- **Climate:** Hot dry sub humid
- **Physiography:** Vindhyan scarplands Baghel khand plateau (Central highlands).
- **Soils:** Deep loamy to clayey mixed red and black soils (Vertic Inceptisols 60%; Alfisols/ Ustolls – 40%)
- **Annual rainfall:** 1335 mm
- **Potential evapotranspiration:** 1342 mm
- **Moisture availability period:** 150-180 days

Sidhi

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

Soil and water conservation

Damoh, Jabalpur, Panna, Rewa, Satna, Shahdol, Sidhi

- Broadbed furrow

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

Mandla

- Bench terracing
- Compartment bunding
- Graded border
- Strips, sowing across the slope and ridging later

Crop management

Damoh, Jabalpur, Mandla, Panna, Rewa, Satna, Shahdol, Sidhi

- **Varieties:**
 - Uplands: Prasanna, Kalinga-III, Govind, IR-50, JR-3-45, Vandana
 - Lowlands: JR-353, IR-36, Jaya, Kranthi, Mahamaya, Karnal Basmati
- **Seed rate:** For broadcasting - 100 kg/ ha; For drilling – 80 kg/ha
- **Planting pattern:** 22.5 cm rows
- **Nutrient management**
 - 40 kg N + 40 kg P₂O₅ /ha.
 - If rainfall is low, all P₂O₅ as basal and N in three splits viz., 50% at sowing, 25% at tillering and 25% at panicle initiation
 - If rainfall is good, 80 kg N in three splits viz., 25% at sowing, 50% at tillering and 25% at panicle initiation
- **Pest management**
 - Gundhi bug: Methyl Parathion 2% dust @ 20-25 kg/ha
 - Green hopper: Carbofuran 3 g @ 15 kg/ha and Monocrotophos 400 g a.i. /ha
 - Climbing cutworm: Endosulfan 600 g a.i /ha, Malathion 0.055 at evening
 - Leaf blast: Hinosan 1 ml/l of water/ Bavistin 1 g/l of water
 - Bacterial leaf blight: Soak seeds in 0.025% water solution of Agrimycin + 0.03% Wettable Sulphur for 12 hours and then transferring the seeds to hot water at 52-54% 0C for 30 minutes.
 - Khaira: 2 kg ZnSO₄ and 1 kg slacked lime 2 spray 10 days interval, immediately after the zinc deficiency symptoms are noticed.
 - Weed control: Complete hand weeding early in the first 30 days after sowing with khurpi and wheel hoe Butachlor @ 2 l as pre emergence in broadcasted rice

Suitable cropping systems

Damoh, Jabalpur, Mandla, Panna, Rewa, Satna, Shahdol, Sidhi

Upland

- Rice upland (JR 3-45) – wheat (306)
- Soybean (J 335) – wheat/ chickpea (JG 315)

- These practices are increasing amongst the farmers
- Mono, sequence and intercropping are described

Monocropping

- Pigeonpea [NP (WR) 15] planted commonly in the farmers field

Sequence cropping

- Rice-wheat
- Rice – chickpea
- Soybean – wheat
- Soybean – chickpea
- Rice – lentil

Intercropping

Kharif

- Sorghum + pigeonpea (2:1)
- Soybean + pigeonpea (2:1)

Rabi

- Wheat + chickpea (2:1)
- Wheat + mustard (2:1 or 4:2)
- Chickpea + linseed (2:1 and others)
- Rice – wheat + chickpea (paired row)

Farm implements/ tools

Damoh, Jabalpur, Mandla, Panna, Rewa, Satna, Shahdol, Sidhi

- Dryland weeder

Alternate farming systems

Jabalpur, Panna, Satna, Sidhi

- Agro – hortisystem: Mango + pea/ berseem (green fodder)/ wheat/ chickpea/ soybean, Mango/guava / amla + Field crops (Wheat, barley, pulses and oilseeds)
- Silvi – pastoral system: Teak + sudan grass
- Fodder/green biomass: *Leucaena leucocephala*, *Albizia amara*, *Dichrostachys cineria*, *Melia azadirach*, *Hardwickia binata*, *A.lebbeck*
- Fruit: Mango, ber, guava, tamarind, karonda
- Medicinal and aromatic plants: *Safed musli*, *Palma rosa*, *Withania somnifera*, *Papaver somniferum*, *Vettiveria zyzanoides*
- Vegetables: Brinjal, chilli, cowpea, okra, bottle gourd, round melon.
- Animal component: Female cattle, male cattle, female buffaloes, goats

Damoh, Mandla

- Agro - hortisystem: Mango/guava / amla + Field crops (wheat, barley, pulses and oilseeds)
- Alley cropping – *Subabul* (4 m interval) + groundnut/sesame/cowpea (grain)

- Fodder/green biomass: *Albizzia lebbeck*, *Subabul*, *Dalbergia sissoo*, *Azadirachta indica*, *Sesbania*, *Pongamia*
- Fruit: Ber, mango sapota, tamarind, fig
- Medicinal and aromatic plants: *Papaver somniferum*, *Rauvolfia*, *Liquorice*, *Safed musli*, *Palma rosa*
- Vegetables: Tomato, okra, bottle gourd, ridge gourd, amaranthus, drumstick
- Animal component: Female and male cattle, female buffaloes, male buffaloes

Shahdhol

- 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 zizanioides*
- Vegetables: Brinjal, chilli, cowpea, okra, bottle gourd, round melon
- Animal component: Female and male cattle, female buffaloes, goats
- Agro - hortisystem: Mango/Guava / amla + Field crops (Wheat, barley, pulses and oilseeds)

Contingent planning

Damoh, Jabalpur, Mandla, Panna, Rewa, Satna, Shahdol, Sidhi

Normal season

- Rice
 - Very early group (less than 95 days): Prasanna, Vandana, JR 3-45
 - Early group (95 to 115 days): IR-64, IR 50, Basmati
 - Medium duration (125 to 145 days): IR-36, Jaya, Kranthi
- Sorghum: CSH 5, CSH 6
- Maize: Ganga-1, Ganga 5
- Pigeonpea: NP (WR) 15
- Soybean: JS 335
- Sesame: JT 7
- Groundnut: Jawahar Jyothi-1
- Kodo kutki: J.kodo 136, J. kutki
- Blackgram: JU 2, DU 4
- Greengram: K851, JM 45

Intercropping

- Sorghum + pigeonpea (2:1)
- Soybean + pigeonpea (2:1)

Late season

- Rice (late variety): IR 50, JR 3-45

- Kodo: JK 155
- Sorghum: CSH 5
- Pigeonpea: JA 4, Asha
- Groundnut: Exotic 1-1
- Blackgram: DU 4
- Sesame: JT-1
- Safflower: JSF 1
- Sunflower: Morden

Late season drought

- Harvested rainwater recycled as life saving irrigation

Lowland – Direct seeded

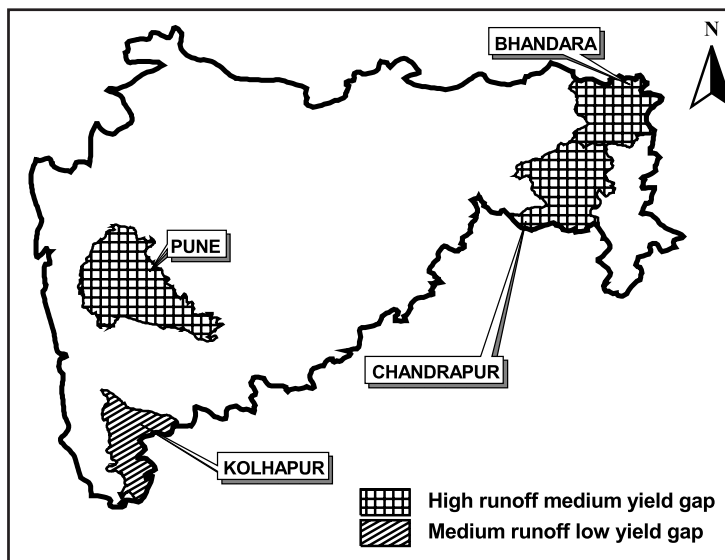
- Re-sowing of rice is needed if plant population is less than 50%
- Weeds are uprooted by manual weeding practice
- Spray of insecticide make sure if attack of insect pest observed
- Spraying of micronutrient if deficiency is noticed

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 seedling from disease and pest attack. When rainfall occurs puddling is done by tractor drawn power tiller, 30-40 days old seedlings should be transplanted, 3 to 4 seedlings/ hills be planted. Adequate fertilizer should be applied as per requirements.

MAHARASHTRA

In Maharashtra there is one district viz. Kolhapur under medium runoff and low yield gap region and three districts viz. Chandrapur, Bhandara and Pune under high runoff and medium yield gap region.



The setting and recommendations follow:

District	Region
Bhandara Chandrapur Pune	High runoff and Medium yield gap

Agro-ecological setting

Bhandara

- **Climate:** Hot moist sub humid
- **Physiography:** Wain ganga valley (Central highlands)
- **Soils:** Shallow to deep loamy to clayey mixed red and black soils (Vertic Inceptisols – 100%)
- **Annual rainfall:** 1349 mm
- **Potential evapotranspiration:** 1638 mm
- **Moisture availability period:** 180-210 days

Chandrapur

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

Pune

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

Soil and water conservation

Pune

- Conservation furrows
- Compartment bunding
- Broad bed furrows
- Gabion structures in waterways
- Semi permanent and *in-situ* conservation measures may be encouraged

Bhandara, Chandrapur

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

Crop management

Bhandara, Chandrapur, Pune

- Locally available upland rice cultivars suited may be adopted.

Farm implements/ tools

Bhandara, Chandrapur

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

Pune

- Tractor multi crop planter: Sowing of *rabi* sorghum was done on farmer's field. Minor modifications made in the original design for adoption of the machine in dryland region. Awareness was created amongst the farmers by conducting demonstrations on farmer's field. The farmers were satisfied with operation of this machine. Rs.22800/-
- Bullock drawn Jyoti Planter: The field trials were conducted and the machine is recommended for sowing the crops of dryland region. Rs.7500/-
- Weeders developed by Maharashtra Agro Industries Development Corporation Ltd. (MAIDC). These weeders were tested on farmer's field and identified for weeding and interculturing in row crops. Rs.410/-

- Tractor drawn Single bottom reversible plough: Tested on farmers' field for ploughing and identified for ploughing operations in dryland region as the field operation was effective and economical. Rs 18500/-
- Tractor drawn Double bottom reversible plough: Tested on farmers' field for ploughing and identified for ploughing operations in dryland region as the field operation was effective and economical. Rs. 23600/-
- Bund former: Bund formers were tested and found suitable for compartment bunding. Rs.1050/-
- Baliram plough: Identified for moisture conservation practices like ridges and furrows and compartment bunding. Rs.2500/-
- Kopergaon bullock drawn two bowl seed drill: The local made seed drill named "Kopergaon seed drill" is operated on the field for sowing crops like sorghum, pearl millet, pigeonpea etc. and identified for sowing of the crops of dryland region. Rs.9000/-

Alternate farming systems

Pune

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

Alternate land use system

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

Bhandara, Chandrapur

- Fodder/green biomass: Stylo sole and stylo-marvel pastoral 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 agri-horticulture system (Ber+short duration Legume crop) was found more remunerative than amla and custard apple horticulture system. Others are pomegranate, ber, mango, sapota, guava, tamarind
- Medicinal and aromatic plants: *Solanum viarum*, *Catharanthus roseus*, *Palma rosa*, *Vetiveria zizanioides*, *Ocimum viride*

- Vegetables: Onion, chilli, brinjal, okra, amaranthus, bottlegourd
- Animal component: Female cattle, male cattle, female buffaloes, goat, poultry

Contingent crop planning

Bhandara, Chandrapur

Regular Monsoon

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

Light soils (20 to 30-35 cm depth)

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

Medium deep soils (35-40 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 (JL - 24) intercropped with sunflower (Morden) in the row ratio of 6:2.

Deep soils (75 cm depth)

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

Delayed onset of monsoon by 15 days

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

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

Regular monsoon followed by long gaps

- Wherever possible, life-saving irrigation is 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 2 per cent concentration, may be useful.
- If there is a total failure of crop, sowing of photo-insensitive crops such as pearl millet (BJ-104) or sunflower (EC-68414) may be attempted.
- In deep soils, the land may be tilled properly. In case, *kharif* crop fails, follow *rabi* crop of safflower (N.7), pigeonpea (C.11) in September.

Continued monsoon

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

Pune

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

- **Second fortnight of June:**
 - All *kharif* crops
- **First fortnight of July:**
 - Pearl millet setaria, groundnut, castor, pigeonpea, horsegram
 - Pearl millet + pigeonpea (2:1)
 - Clusterbean + pigeonpea (2:1)
 - Clusterbean + castor (2:1)
 - Sunflower + pigeonpea (2:1)
- **Second fortnight of July:**
 - Sunflower, pigeonpea, horsegram, setaria
 - Castor, pearl millet (ergot resistant)
 - Sunflower + pigeonpea (2:1)
- **First fortnight of August:**
 - Sunflower, pigeonpea, castor, horsegram
 - Sunflower + pigeonpea (2:1)
- **Second fortnight of August:**
 - Sunflower, pigeonpea, castor
 - Sunflower + pigeonpea (2:1)
- **First fortnight of September:**
 - Sorghum for fodder
- **Second fortnight of September:**
 - *Rabi* Sorghum, Safflower, Sunflower
- **First fortnight of October:**
 - *Rabi* Sorghum, Safflower, Chickpea, Sunflower
- **Second fortnight of October:**
 - Chickpea, Sunflower, *rabi* sorghum
- **First fortnight of November:**
 - Chickpea, Sunflower.

Alternate farming systems

Chandrapur

- **Fodder/ Green biomass:** *Leucaena Leucocephala*, *Albizia lebbeck*, *Dalbergia sissoo*, *Azadirachta indica*, *A. procera*, *Gliricidia*
- **Fruit:** Pomegranate, Ber, Mango, Sapota, Guava, Tamarind

- **Medicinal/ Aromatic Plants:** *Solanum viarum*, *Catharanthus roseus*, *Palma rosa*, *Vetiveria zizanoides*, *Ocimum viride*
- **Vegetables:** Onion, Chilli, Brinjal, Okra, Amaranthus, Bottle gourd.
- **Animal Component:** Male/ Female cattle, Female buffaloes, Sheep, Goat, Poultry

District	Region
Kolhapur	Medium runoff and Low yield gap

Agro-ecological setting

- **Climate:** Hot dry sub humid/ Hot moist sub humid to humid (transitional)
- **Physiography:** North Karnataka plateau / South loamy western Maharashtra plateau
- **Soils:** Shallow and medium loamy and clayey black soils, deep clayey black soils, Deep to clayey red and lateritic soils (Vertisols – 50%; Vertic Inceptisols – 50%)
- **Annual Rainfall:** 1137 mm
- **Potential Evapotranspiration:** 1636 mm
- **Moisture availability period:** 150-270 days

Soil and water conservation

- Conservation furrows
- Compartment bunding
- Broad bed furrows
- Gabion structures in waterways
- More emphasis could be given on permanent structures

Crop management

- Locally available upland rice cultivars may be adopted.

Farm implements/ tools

- Tractor multicrop planter: Sowing of *rabi* sorghum was done on farmer's field. Minor modifications made in the original design for adoption of the machine in dryland region. Awareness was created among farmers by conducting demonstrations on farmer's field. The farmers were satisfied with operation of this machine. (Rs.22800/-)
- Bullock drawn Jyoti Planter: The field trials were conducted and the machine is recommended for sowing the crops of dryland region. (Rs.7500/-)
- Weeders developed by Maharashtra Agro Industries Development Corporation Ltd. (MAIDC): These weeders were tested on farmer's field and identified for weeding and interculturing in row crops. (Rs.410/-)
- Single bottom reversible plough: Tested on farmers' field for ploughing and identified for ploughing operations in dryland region as the field operation was effective and economical. (Rs.18500/-)
- Double bottom reversible plough: Tested on farmers' field for ploughing and identified for ploughing operations in dryland region, as the field operation was effective and economical. (Rs.23600/-)
- Bund former: Bund formers were tested and found suitable for compartment bunding (Rs.1050/-)
- Baliram plough: Identified for moisture conservation practices like ridges and furrows and compartment bunding (Rs.2500/-)

- Kopergaon bullock drawn two bowl seed drill: The local made seed drill named “Kopergaon seed drill” is operated on the field for sowing crops like sorghum, pearl millet, pigeonpea etc. and identified for sowing of the crops of dryland region (Rs.9000/-)

Alternate farming system

- Silviculture: Leucaena + Marvel –8
- Alley cropping: Ber (20 m alleys) + pearl millet + pigeonpea for shallow soils
- Fodder: Maize (African Tall), Oats (Kent) *Stylosanthes hamata*
- Fodder/ green biomass: *Dalbergia sissoo*, *Albizia lebbek*, *Anogeissus latifolia*, *Sesbania*, *Stylo Marvel – 8 grass*
- Fruit: Ber, custard apple, pomegranate, amla + *kharif* spreading crops
- Medicinal/ Aromatic Plants: *Catharanthus roseus*, *Palma rosa*, *Vetiveria zizanioides*, *Rose*, *Geranium*
- Vegetables: Onion, tomato, okra, cowpea, cluster bean, drumstick
- Animal Component: Male/ female cattle, female buffaloes, sheep, goat
 - Cow breeds: Gir, Jersey
 - Poultry: White Leghorn
 - Rams

Alternate land use system:

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

Contingent planning

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

Second fortnight of June

- All *kharif* crops

First fortnight of July

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

Second fortnight of July

- Sunflower, pigeonpea, horsegram, setaria
- Castor, pearl millet (ergot resistant)

- Sunflower + pigeonpea (2:1)

First fortnight of August

Sunflower, pigeonpea, castor, horsegram

- Sunflower + pigeonpea (2:1)

Second fortnight of August

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

First fortnight of September:

- Sorghum for fodder
- Second fortnight of September: *Rabi* sorghum, safflower, sunflower

First fortnight of October:

- *Rabi* Sorghum, safflower, chickpea, sunflower

Second fortnight of October:

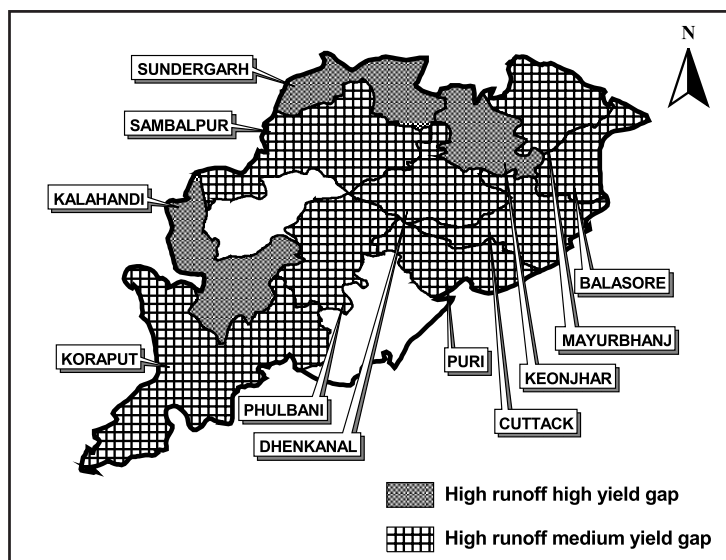
- Chickpea, sunflower, *rabi* sorghum

First fortnight of November

- Chickpea, sunflower

ORISSA

In Orissa there are eight districts viz. Dhenkanal, Cuttack, Koraput, Phulbani, Puri, Sambalpur, Mayurbhanj and Balasore under high runoff and medium yield gap region and three districts viz. Sundergarh, Keonjhar and Kalahandi under high runoff and high yield gap region.



The setting and recommendations follow:

District	Region
Balasore	High runoff and Medium yield gap
Cuttack	
Dhenkanal	
Koraput	
Mayurbhanj	
Phulbani	
Puri	
Sambalpur	

Agro-ecological setting

Balasore

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

Cuttack

- **Climate:** Hot (moist/ dry) sub humid
- **Physiography:** Eastern ghats (Gangetic delta)

- **Soils:** Medium to deep loamy red and lateritic, deep loamy to clayey coastal and Deltaic alluvium - derived soils, Deep loamy to clayey coastal and deltaic alluvium - derived soils (Alfisols – 60%; Aridisols – 40%)
- **Annual rainfall:** 1559 mm
- **Potential evapotranspiration:** 1504 mm
- **Moisture availability period:** 180-210 days

Dhenkanal

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

Koraput

- **Climate:** Hot moist sub humid
- **Physiography:** Eastern ghats
- **Soils:** Deep loamy red and lateritic soils (Alfisols – 100%)
- **Annual rainfall:** 1671 mm
- **Potential evapotranspiration:** 1630 mm
- **Moisture availability period:** 180-210 days

Mayurbhanj

- **Climate:** Hot moist sub humid
- **Physiography:** Eastern ghats
- **Soils:** Deep loamy red and lateritic soils (Alfisols/ Ustolls – 65%; Alfisols – 35%)
- **Annual rainfall:** 1361mm
- **Potential evapotranspiration:** 1641 mm
- **Moisture availability period:** 180-210 days

Phulbani

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

Puri

- **Climate:** Hot moist/ dry sub humid

- **Physiography:** Eastern ghats, coastal orissa
- **Soils:** Medium to deep loamy red and lateritic, deep loamy to clayey coastal and Deltaic alluvium derived soils (Aridisols – 50%; Alfisols – 50%)
- **Annual rainfall:** 1440 mm
- **Potential evapotranspiration:** 1730 mm
- **Moisture availability period:** 180-210 days

Sambalpur

- **Climate:** Hot moist sub humid
- **Physiography:** Northern orissa
- **Soils:** Deep loamy red and lateritic soils (Alfisols/ Ustolls – 100%)
- **Annual rainfall:** 1764 mm
- **Potential evapotranspiration:** 1452 mm
- **Moisture availability period:** 180-210 days

Soil and water conservation

Balasore, Cuttack, Dhenkanal, Mayurbhanj, Phulbani, Puri

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

Sambalpur

- Ridges and furrows
- Emphasis on permanent soil and water conservation measures
- Water harvesting structures, ponds etc. need to be created for storage of runoff for supplemental utilization for second crop
- *In-situ* conservation measures in uplands and midlands.
- Suitable drainage measures for low lands.

Crop management

Balasore, Cuttack, Dhenkanal, Koraput, Mayurbhanj, Phulbani, Puri, Sambalpur

- **Varieties:** Vandana, Pathara, Kalinga-III, Vanaprabha, Sneha and Anjali
- **Seed rate:**
 - Upland rice -100 kg /ha
 - Medium land rice – 50 to 75 kg /ha
- **Planting pattern:**
 - Upland rice - 15-20 cm
 - Medium land rice – 15x10, 15x15, 20x10 and 20x15 cm

- **Nutrient management**

Crop	Nutrients (kg/ha)			Mode of application		
	N	P ₂ O ₅	K ₂ O	Basal	First top dressing	Second top dressing
Upland rice						
(i) Local	30	20	20	All P & K, 25% N	50% N at 21 days after germination	25% N at panicle initiation stage
(ii) Improved	40	20	20	-do-	-do-	-do-
(iii) High yielding	60	30	30	-do-	-do-	-do-
Medium land rice						
(i) Local	50	25	25	All P & K, 25% N at transplanting	50% N three weeks after transplanting	25% N at panicle stage initiation
(ii) Improved	60	30	30	-do-	-do-	-do-
(iii) High yielding	80	40	40	-do-	-do-	-do-

Pest Management

Balasore, Cuttack, Dhenkhenal, Koraput, Mayurbhanj, Phulbani, Puri, Sambalpur

- *Microtermes obesi* is a key pest in this ecosystem forms one of the main constraints to achieve the desired yield. Termite population is more prevalent in red laterite soil. They attack the root portion of the plant which results in yellowing of plant
- Crop stand losses due to the termite were estimated to be as high as 90%. Termites attack rice plant right from germination to maturity and the popularly grown rice varieties do not have resistance against this pest. Thus, it is imperative to take prophylactic measures to manage this pest with chemicals.
- Treating paddy seeds with chlorpyrifos @ 750 g a.i./100 kg seeds will check the termite attack and result in increasing the grain yield. Besides chlorpyrifos, imidacloprid and fipronil @ 200 g a.i./100 kg seeds were also found promising.

Suitable cropping systems

Balasore, Cuttack, Dhenkanal, Koraput, Mayurbhanj, Phulbani, Puri, Sambalpur

Uplands

- **Sequence cropping:** Rice (Vandana/ Heera) – Horsegram (Urmi/ local)/ Rapeseed mustard (M-27, PT-303)
- **Relay cropping:** Rice (Heera) + horsegram (Urmi, local) and Rice (ZHU 11- 26, Heera) + pigeonpea (UPAS 120)
- **Inter cropping:**
 - Rice (Vandana) + radish (Pusa chetki): Four rows of rice in 15 cm apart rows are grown in 75 cm interspace between paired rows of radish with set specification 30 (radish) – 75 (rice) – 30 cm (radish).
 - Rice (ZHU 11-26) + Okra (Parbhani kranthi): Four rows of rice in 15 cm apart rows are grown in 75 cm space between paired rows of okra with set specification 30 (okra) – 75 (rice) – 30 cm (okra).
 - Rice (ZHU 11-26) + blackgram (Pant U 30)/ greengram (PDM 54): Five rows of rice, spaced at 15 cm, are sown between paired rows of blackgram/ greengram with set specification 30 (blackgram/ greengram) – 90 (rice) – 30 cm (blackgram/ greengram). The blackgram varieties are ready for harvest in 60-70 days.
 - Rice and blackgram/ greengram may be grown in 2:1 row ratio. If rice crop fails in drought years, pulse crop is maintained. If rainfall is normal, pulse crop is cut for fodder and rice crop is maintained.

Medium lands:

- **Sequence cropping:**
 - Rice (Lalat, Konark) – Linseed (Kiran, Laxmi 27 and Pusa 3)
 - Rice (Lalat, Konark) – Rapeseed mustard (PT 303, M-27, Local rai)
- **Paira cropping:** Rice (Lalat, Konark, Jajati, Swarna) – Lathyrus (Local).

Low land:

- **Sequence cropping:** Rice (CR 1014, Utkal Prabha) – greengram (PDM-54)
- **Relay cropping:** Rice (CR 1014, Utkalprabha) – Lathyrus

Jhola land: Rice

- Alternate crops – Mesta – AMV –1, AS –7
- Safflower – S-2-27, A-300
- Pearl millet – BPC-39, IP-417
- Soybean – JS – 1, Punjab –1
- Turmeric – Sudarshan
- Ginger – Nadia

Farm implements/ tools

Cuttack, Koraput, Dhenkenal, Phulbani, Puri, Sambalpur

- Fertilizer cum seed drill

Alternate farming systems

Balasore

Non – arable wastelands:

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

Arable wastelands:

- Agri - horticulture: Fruit crops (mango/ citrus/ sapota/ pomegranate/ custard apple/ amla/ litchi/ jackfruit/ phalsa) + field crops (pulses/ oilseeds). Hybrid mango varieties viz. Pusa Amrapalli and Pusa Mallika are becoming increasingly popular in the zone.
 - Sweet potato + maize/castor (spacing 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
- Tree on crop lands: *Albizzia spp*, *Cassia siamea*, *Gravellea robusta*, *Dalbergia sissioo*
- Fruit: Mango, Jackfruit, guava, Lime.
- Medicinal/aromatic plants: *Vetiveria zyzanoides*, *Cymbopogan flexuous*, *Palma rosa*, *Solanum viarum*, *Cinnemon*, *Citronella fara*.

- Vegetables: Bottle gourd, ridge gourd, watermelon, long melon, tomato, brinjal.
- Animal component: Female buffalo, sheep, goat

Cuttack, Koraput

Non – arable wastelands:

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

Arable wastelands:

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

Mayurbhanj

- Alley cropping: *Subabul* (4 m interval) + groundnut/ sesame/ cowpea (grain)
- Silviculture/ social forestry – for denuded eroded, highly sloppy and shallow lands
- Horticulture – in uplands- Mango, litchi, guava, lemon, custard apple, jack fruit
- Agro-horti system: Sweet potato + maize/ castor (spacing 80 x 25 cm), Yam (100 x 60 cm) + maize/ castor, Tapioca (100 x 100 cm) + maize/ castor, Colocassia (80 x 25 cm) + maize/ castor
- Fodder/green biomass: *P.pinnata*, *Albizzia sps*, *Cassia siamea*, *Gravellea robusta*, *Dalbergia sissoo*, *Azadirachta indica*
- Fruit: Mango, jack fruit, guava, lime
- Medicinal and aromatic plants: *Vetiveria zyzanoides*, *Cymbopogan flexuosus*, *Palma rosa*, *Solanum viarum*, *Cinnamon*, *Citronella java*
- Vegetables: Bottle gourd, brinjal, ridge gourd, water melon, long melon, bitter gourd, tomato
- Animal component: Female cattle, male cattle, goat

Sambalpur

• Agro-horti system:

- Sweet potato + maize/ castor (spacing 80 x 25 cm)
- Yam (100 x 60 cm) + maize/ castor
- Tapioca (100 x 100 cm) + maize/ castor
- Colocasia (80 x 25 cm) + maize/ castor
- Alley cropping: *Subabul* (4 m interval) + groundnut/ sesame/ cowpea (grain)
- Fodder/ green biomass: *Dalbergia sissoo*, *Albizia lebbeck*, *Anogeissus latifolia*, *Sesbania*, *Stylo*, *Marvel* – 8 grass
- Fruit: Ber, custard apple, pomegranate, amla + *kharif* spreading crops.
- Medicinal and aromatic plants: *Catharanthus roseus*, *Palma rosa*, *Vetiveria zizanioides*, *Rose*, *Geranium*
- Vegetables: Onion, tomato, okra, cowpea, cluster bean, drumstick

Non – arable wastelands:

- Silviculture: Sal, Teak
- Silvipastoral system: *Shisham*/ *Subabul*/ *Gambar* + *Stylo*/ *Cenchrus*

Arable wastelands:

- Agri-horticulture: Fruit crops (mango/ citrus/ sapota/ pomegranate/ custard apple/ amla/ litchi/ jackfruit/ phalsa) + field crops (pulses/ oilseeds). Hybrid mango varieties viz. Pusa Amrapalli and Pusa Mallika are recommended.
- Alley cropping: *Subabul* + turmeric/ ginger

Contingent crop planning

Balasore, Cuttack, Dhenkanal, Koraput, Phulbani, Puri, Sambalpur

Normal season:

- Rice:
 - Very early group (less than 95 days): Heera, Rudra, Vandana and Anjali
 - Early group (95 to 115 days): Pathara, Khandagiri, Udayagiri, Ghanteswari & Parijat
 - Early medium (115 to 120 days): Sarathi & Bhoi
 - Medium duration (125 to 145 days): Lalat, IR-64, Konark, Gajapati, Surendra, Jajati, Swarna, MTU-1001 and Padmini
 - Late duration: Utkalaprava, Gayatri, Savitri, Prachi, Ramachani, Mahanadi and Indrabati
- Finger millet: Dibyasinha, Nilachala, Bhairabi and Subhra
- Maize: Navjot, Vijaya, DHM-103 and Ganga-5
- Greengram: PDM-54, K- 851, Dhauri and TARM-2
- Blackgram: Pant U-30, T-9 and Sarala
- Pigeonpea: UPAS-120, R-60, T-21 and S-5
- Cowpea: SEB-2, SGL-1 and Arka Kamal
- Horsegram: Urmi and Local
- Groundnut: Smruti (OG 52-1), JL-24, ICGS-11 and AK 12-24

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

Aberrant weather:

Upland

Early season drought/ Delay in onset of monsoon:

- When upland rice is completely damaged, the crop may be cut down for supplying fodder to the cattle. Non-rice crops viz. finger millet (Subhra, Bhairabi, Dibyasingha and Godavari), greengram (K 851, PDM-11 and PDM-54), blackgram (T-9, Sarala and Pant U-30), cowpea (SEB-2, SGL-1, Arka Kamal), horsegram (Urmi), ricebean (RBL 6), sesame (Usha, Uma) and castor (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 finger millet 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 l solution.
- Excess plants in the crop row should be thinned to reduce moisture loss from the soil.
- Use of tender twigs of *Subabul*, *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, puddling is done by tractor drawn powertiller or rotovator for better puddling. Close planting of 45-day old seedlings in case of medium duration varieties and 60-70 day old seedlings in late varieties should be done. There should be 60-65 hills/m². Instead of 2 to 3 seedlings, 4 to 5 seedlings/hill should be planted. Adequate fertilizer should be applied at transplanting.
- When seedlings are insufficient, they may be raised by 'Dapog' method.

Mayurbhanj

Normal sowing period (15th to 30th June)

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

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

Delayed sowing period (1 – 7 July)

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

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

- Transplanting of finger millet (all varieties) but spacing to be reduced from 20 x 15 to 20 x 10 cm
- Greengram: Sunaina

- Blackgram: T.9
- Sesame: Kanke white (normal sowing time), Krishna
- Sweet potato: Cross 4 and Local (normal sowing time)
- Beyond July it is much too late for general crops. However, if seedlings are available transplanting of finger millet could be resorted to in early August. Niger (N.5) and horsegram (BR. 10 Madhu) are the natural choice for August seeding

General precautions in case of delayed sowing

- Pre-monsoon tillage will pay dividends under such a situation in keeping weeds under control.
- Crops should be spaced a little closer to compensate for loss in growing period.
- Heavier dose of basal nitrogen and less number of splits should be followed specially in short duration crops.

Under these conditions, since there is possibility of continuous rains proper care should be taken for the drainage of upland crops, which suffer from water logging at emergence state and some even at later stages.

District	Region
Kalahandi Keonjhar Sundergarh	High runoff and High yield gap

Agro-ecological setting

Kalahandi

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

Keonjhar

- **Climate:** Hot moist sub humid
- **Physiography:** Garjat hills
- **Soils:** Moderately deep loamy to clayey red and Lateritic soils Alfisols/ Ustolls – 65%; Alfisols – 35%
- **Annual rainfall:** 1422 mm
- **Potential evapotranspiration:** 1998 mm
- **Moisture availability period:** 150-180 days

Sundergarh

- **Climate:** Hot moist sub humid
- **Physiography:** Chattisgarh / Mahanandi basin
- **Soils:** Deep loamy red and lateritic soils (Alfisols/ Ustolls – 100%)

- **Annual rainfall:** 1572 mm
- **Potential evapotranspiration:** 1624 mm
- **Moisture availability period:** 180-210 days

Soil and water conservation

Kalahandi, Keonjhar, Sundergarh

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

Crop management

Kalahandi, Keonjhar, Sundergarh

- **Varieties:** Vandana, Pathara, Vanaprabha and Anjali
- **Seed rate:**
 - Upland rice -100 kg/ha
 - Medium land rice – 50 to 75 kg/ha
- **Planting pattern:**
 - Upland rice - 15-20 cm
 - Medium land rice – 15 – 20 x 10 –15 cm
- **Integrated nutrient management**

Crop	Nutrients (kg/ha)			Mode of application		
	N	P ₂ O ₅	K ₂ O	Basal	First top dressing	Second top dressing
Upland rice						
Local	30	20	20	All P & K, 25% N	50% N at 21 days after germination	25% N at PI stage
Improved	40	20	20	-do-	-do-	-do-
High yielding	60	30	30	-do-	-do-	-do-
Medium land rice						
Local	50	25	25	All P & K, 25% N at transplanting	50% N three weeks after transplanting	25% N at PI stage
Improved	60	30	30	-do-	-do-	-do-
High yielding	80	40	40	-do-	-do-	-do-

Suitable cropping systems

Kalahandi, Keonjhar, Sundergarh

Uplands

- **Sequence cropping:** Rice (Vandana/ Heera) – horsegram (Urmi/ local)/ rapeseed mustard (M-27, PT-303)

- **Relay cropping:** Rice (Heera) + horsegram (Urmi, local) and Rice (Heera) + pigeonpea (UPAS 120)
- **Inter cropping:**
 - Rice (Vandana) + radish (Pusa chetki): Four rows of rice in 15 cm apart rows are grown in the 75 cm inter space between paired rows of radish with set specification 30 (radish) – 75 (rice) –30 cm (radish).
 - Rice + Okra (Parbhani kranthi): Four rows of rice in 15 cm apart rows are grown in 75 cm space between paired rows of okra with set specification 30 (okra) – 75 (rice) – 30 cm (okra).
 - Rice + blackgram (Pant U 30)/ greengram (PDM 54): Five rows of rice, spaced at 15 cm, are sown between paired rows of blackgram/ greengram with set specification 30 (blackgram/ greengram) – 90 (rice) – 30 cm (blackgram/ greengram). The blackgram varieties are ready for harvest in 60-70 days.
 - Rice and blackgram/ greengram may be grown in 2:1 row ratio. If rice crop fails in drought years, pulse crop is maintained. If rainfall is normal, pulse crop is cut for fodder and rice crop is maintained.

Medium lands:

- **Sequence cropping:**
 - Rice (Lalat, Konark) – linseed (Kiran, Laxmi 27 and Pusa 3)
 - Rice (Lalat, Konark) – rapeseed mustard (PT 303, M-27, Local rai)
- **Paira cropping:** Rice (Lalat, Konark, Jajati, Swarna) – lathyrus (Local).

Low land:

- Sequence cropping: Rice (CR 1014, Utkal Prabha) – greengram (PDM-54)
- Relay cropping: Rice (CR 1014, Utkalprabha) - lathyrus

Jhola land:

- Rice

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 and Tools

Keonjhar

- Mould board plough: Suitable for primary tillage (1st and 2nd ploughing), Requires a pair of bullock and covers 0.3 ha/ day. Rs.252/-
- Heavy soil plough: Suitable for black cotton soil, requires a pair of bullock and covers 0.24 ha/ day. Rs.324/-
- Cast iron plough: Suitable for ploughing and puddling in fields free from roots of trees and pebbles, Requires a pair of bullock and covers 1.0 ha/ day. Rs.266/-
- Zig-zag puddler: Puddling , requires a pair of bullock and covers 1.0 ha/ day. Rs.1788/-
- IADP Pubbler: Pulverizing light sandy loamy soil, Puddling, Suitable for heavy soils of western Orissa, Requires a pair of bullock and covers 1.0 ha/ day. Rs.1700/-

- Puddler 99: Pulverising all soils, Puddling, Requires a pair of bullock and covers 1.0 ha/ day. Rs.1232/-
- One row seed drill: Seed sowing in rice, maize and groundnut, requires a pair of bullock and covers 0.3 ha/ day. Rs. 246/-
- Two row multicrop seed drill: Seed sowing in rice, wheat, groundnut and bengalgram, requires a one man and covers 0.5 ha/ day. Rs. 1164/-
- Two row mustard seed drill: Mustard sowing, requires a one man and covers 0.5 ha/ day. Rs.827/-
- Three row multicrop seed drill: Seed sowing in rice, wheat, bengalgram and groundnut, requires a one man and covers 0.8 ha/ day. Rs.1570/-
- Paddy transplanter (Manual): Transplanting paddy with proper spacing, Requires a two men and covers 20 ha/ day. Rs.4000/-
- Pedal paddy thresher: Threshing of paddy, Requires a two men and covers 2.5 q/ day. Rs.2754/-
- Power paddy thresher: Threshing of paddy, Requires a electric motor (1 HP) and covers 10-12 q/ day. Rs.8778/- (With motor and starter)
- Groundnut digger: Digging groundnut, Requires a pair of bullock and covers 0.3 ha/ day. Rs.548/-
- Pedal groundnut thresher: Separating groundnut pods from the plants, Requires a two men and covers 2.2 q pods/ day. Rs.2818/-
- Groundnut decorticator: Spreading seeds from groundnut pods, Requires a one men and covers 50 kg/ hour. Rs. 764/-
- Maize Sheller: Spreading seeds from maize cobs, Requires a one man and covers 1.0 q/ day. Rs. 25/-

Kalahandi

- Fertilizer cum seed drill

Alternate farming systems

Sundergarh

- Agro-horti system: Sweet potato + maize/ castor (spacing 80 x 25 cm)
- Yam (100 x 60 cm) + maize/ castor
- Tapioca (100 x 100 cm) + maize/ castor
- Colocassia (80 x 25 cm) + maize/ castor
- Alley cropping: *Subabul* (4 m interval) + groundnut/ sesame/ cowpea (grain)
- Fodder/ green biomass: *P.pinnata*, *Albizzia sps*, *Cassia siamea*, *Grevillea robusta*, *Dalbergia sissoo*, *Azadirachta indica*
- Fruit: Mango, jack fruit, guava, lime
- Medicinal and aromatic plants: *Vetiveria zyzanoides*, *Cymbopogan flexuosus*, *Palma rosa*, *Solanum viarum*, *Cinnamon*, *Citronella java*
- Vegetables: Bottle gourd, brinjal, ridge gourd, water melon, long melon, bitter gourd, tomato
- Animal component: Female cattle, male cattle, goat

Kalahandi, Keonjhar

- Fodder/ green biomass: *Dalbergia sissoo*, *Albizzia lebbeck*, *Anogeissus latifolia*, *Sesbania*, *Stylo Marvel* – 8 grass

- Fruit: Ber, Custard apple, Pomegranate, amla+ *kharif* spreading crops.
- Medicinal/ Aromatic Plants: *Catharanthus roseus*, *Palma rosa*, *Vetiveria zizanioides*, *Rose*, *Geranium*
- Vegetables: Onion, tomato, okra, cowpea, cluster bean, drumstick

Non – arable wastelands:

- Silviculture: Sal, Teak
- Silvi-pastoral system; Shisham/ *Subabul*/ Gambar + *Stylo*/ *Cenchrus*

Arable wastelands:

- Agri-horticulture: Fruit crops (mango/ citrus/ sapota/ pomegranate/ custard apple/ amla/ litchi/ jackfruit/ phalsa) + field crops (pulses/ oilseeds). Hybrid mango varieties viz. Pusa Amrapalli and Pusa Mallika are becoming increasingly popular in the zone.
- Sweet potato + maize/castor (spacing 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

Contingent crop planning

Kalahandi, Keonjhar, Sundergarh

Normal season

- Rice:
 - Very early group (less than 95 days): Heera, Rudra, Vandana and Anjali
 - Early group (95 to 115 days): Pathara, Khandagiri, Udayagiri, Ghanteswari & Parijat
 - Early medium (115 to 120 days): Sarathi & Bhoi
 - Medium duration (125 to 145 days): Lalat, IR-64, Konark, Gajapati, Surendra, Jajati, Swarna, MTU-1001 and Padmini
 - Late duration: Utkalaprava, Gayatri, Savitri, Prachi, Ramachani, Mahanadi and Indrabati
- Finger millet: 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 and Kamal
- Horsegram: Urmi and Local
- Groundnut: Smruti (OG 52-1), JL-24, ICGS-11 and AK 12-24
- Castor: Aruna, DCH-177 and DCH-30
- Rapeseed mustard: PT- 303, M-27, Parvati and Anuradha
- Sesame: Vinayak, Uma, Usha and Prachi

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

Aberrant weather

Upland

Early season drought/ Delay in onset of monsoon

When upland rice is completely damaged, the crop may be cut down for supplying fodder to the cattle. Non-rice crops viz. Finger millet (Subhra, Bhairabi, Dibyasingha and Godavari), greengram (K 851, PDM-11 and PDM-54), blackgram (T-9, Sarala and Pant U-30), cowpea (SEB-2, SGL-1, Arka Kamal), horsegram (Urmi), ricebean (RBL 6), sesame (Usha, Uma), castor (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 finger millet 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 *Subabul*, *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:

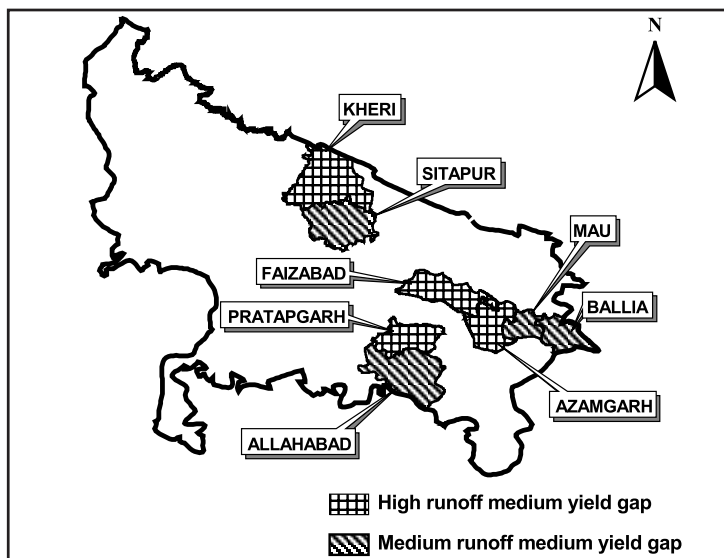
- Re-sowing of rice is needed if plant population is less than 50%. Line sowing of pre-germinated seeds of rice (125 days duration) should be done. Nursery for comparatively shorter duration rice varieties may be done.
- If plant population is more than 50% and 'beushening' is not possible, weeds are 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, puddling is done by tractor drawn power tiller or rotovator for better puddling. Close planting of 45-day old seedlings in case of medium duration varieties and 60-70 day old seedlings in late varieties should be done. There should be 60-65 hills/m². Instead of 2 to 3 seedlings, 4 to 5 seedlings/hill should be planted. Adequate fertilizer should be applied at transplanting.
- When seedlings are insufficient, they may be raised by 'Dapog' method.

UTTAR PRADESH

In Uttar Pradesh there are five districts viz. Allahabad, Ballia, Mau, Sitapur and Sultanpur under medium runoff and medium yield gap region and four districts viz. Azamgarh, Kheri, Faizabad and Pratapgarh under high runoff and medium yield gap region.



The setting and recommendations follow:

District	Region
Allahabad	Medium runoff and Medium yield gap
Ballia	
Mau	
Sitapur	
Sultanpur	

Agro-ecological setting

Allahabad

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

Ballia

- **Climate:** Hot moist / dry sub humid
- **Physiography:** Aradh plains (Northern plains)
- **Soils:** Deep loamy alluvium derived soils, Deep, loamy alluvium - derived soils (Inceptisols – 100%)

- **Annual rainfall:** 1085 mm
- **Potential evapotranspiration:** 1492 mm
- **Moisture availability period:** 150-210 days

Mau

- **Climate:** Hot dry sub humid/ Hot/ moist sub humid
- **Physiography:** Aradh plains (Northern plains)
- **Soils:** Deep loamy alluvium derived soils, deep loamy alluvium - derived soils (Inceptisols – 100%)
- **Annual rainfall:** 948 mm
- **Potential evapotranspiration:** 1504 mm
- **Moisture availability period:** 150-210 days

Sitapur

- **Climate:** Hot dry sub humid
- **Physiography:** Kohil khand plains (Northern plains)
- **Soils:** Deep loamy alluvium derived soils (Inceptisols – 100%)
- **Annual rainfall:** 1099 mm
- **Potential evapotranspiration:** 1411 mm
- **Moisture availability period:** 150-180 days

Sultanpur

- **Climate:** Hot dry sub humid
- **Physiography:** Aradh plains (Northern plains)
- **Soils:** Deep loamy alluvium derived soils (Inceptisols – 100%)
- **Annual rainfall:** 1111 mm
- **Potential evapotranspiration:** 1515 mm
- **Moisture availability period:** 150-180 days

Soil and water conservation

Allahabad

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

Ballia, Mau, Sitapur, Sultanpur

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

Crop management

Allahabad

- **Varieties:** NDR-97, NDR-118, Govind
- **Seed rate:** 100 kg/ha
- **Planting pattern:** 30 cm rows and thick intra rows
- **Nutrient management**
 - 80 kg N + 40 kg P₂O₅ + 30 kg K₂O/ha.
 - During *kharif* place N basal in seed furrows and remaining topdress when surface is moist (30 to 40 days after seeding). In *rabi* place fertilizer 10-15cm deep in the seed furrows. Apply P₂O₅ and K₂O based on soil test basis to these crops
 - In upland rice use of Agromin (chelated micronutrients) @ 0.16% solution spray when crop is about 45 days old helps in increasing yield.
 - On availability of organic source of fertilizer, its conjunctive use along with chemical fertilizers in proportion of 50:50 has confirmed its utility in sustaining the productivity of component crops in the proven system due to improved soil health.
- **Pest management:**
 - Stem borer: Dusting of Furadon @ 15-16 Kg/ha 30 days after sowing is recommended
 - Gundhi bugs: Spray Endosulphan @ 2.5 ml/L
 - Army worms: Apply Folidol @ 15-20 kg/ha at heading stage (after sunset)
- **Weed management**
 - Keep upland rice fields weed free for the first 30 to 40 days followed by either mechanical or chemical control measures. Weed free upto 30 days after sowing in *kharif* crops in all other crops
- **Mechanical**
 - Dryland weeder 25-30 and 45-50 days after sowing
- **Chemical**
 - Preemergence application of Butachlor @2-0 kg (a.i)/ha in upland rice
- **Integrated - mechanical and chemical**
 - Preemergence application of Butachlor @ 4 to 7kg (a.i)/ha and one interculture by dry land weeder 30 days after sowing
- **Disease management**
 - Blight disease: spray mixture of 75 g Agrimycin, 2 kg Diathane Z-78 and 1 l Thiodon dissolved in 100 l of water in one ha.

Ballia, Mau, Sitapur, Sultanpur

- **Varieties:** NDR-97, NDR-118, Govind and Vandana
- **Seed rate:** 100 kg/ha
- **Planting pattern:** 30 cm rows and thick intra rows
- **Nutrient management**

- 80 kg N + 40 kg P₂O₅ + 30 kg K₂O/ha.
- During *kharif* place N basal in seed furrows and remaining top dress when surface is moist (30 to 40 days after seeding). In *rabi* place fertilizer 10-15 cm deep in the seed furrows
- **Pest management:**
- Keep upland rice fields weed free for the first 30 to 40 days followed by either mechanical or chemical control measures.

Mechanical:

Time of operation	Implement/tool	Remarks
10-40 days after sowing	Hand weeding or mechanical with sweep hoe/dryland weeder	Keep the field free of weeds in the first 40 days. Work 2 to 3 times

Chemical:

Herbicide	Litres/ha	Mode of application
Butachlor + 2,4-D	2,4.0+0.5	Pre-emergence+ 30 DAS

Integrated weed management

Chemical	Mechanical	Remarks
Butachlor @ 4 to7/ha as pre-emergence	One interculture by dry land weeder 30 DAS	Keep the field free of weeds in the first 4 days. Work 2 to 3 times
Pendimethalin 3L/ha as PE	Do	-do-

- Stem borer: Dusting of Furadon @ 15-16 Kg/ha 30 days after sowing is recommended
- Gundhi bugs: Spray Endosulphan @ 2.5 ml/L
- Army worms: Apply Folidol @ 15-20 kg/ha at heading stage (after sunset)
- Blight disease: Spray mixture of 75 g Agrimycin, 2 kg Diathane Z-78 and 1 l Thiodon dissolved in 100 l of water in one ha.

Some other important practices

- Line sowing
- Sow upland rice after monsoon sets in and when 15-20 cm soil layer is wet

Suitable cropping systems

Allahabad

Water availability period (days)	Double cropping system	Intercropping system
Inceptisols and related soils		
200-230	Rice – chickpea	Chickpea + mustard (4:1)
	Rice – lentil	Maize+ blackgram (1:1)
	Rice – mustard	Pigeonpea + blackgram (1:1)
	Maize – lentil	Pigeonpea + sesame (1:1)
		Pigeonpea + groundnut (1:2)
180-200		Barley + mustard (6:1)
	Pearlmillet – chickpea	Pear+ pigeonpea (2:1)

Water availability period (days)	Double cropping system	Intercropping system
Inceptisols and related soils		
	Greengram – mustard	Chickpea + mustard (4:1)
	Greengram – barley	Chickpea + barley (2-3:1)
	Blackgram- mustard	Chickpea + linseed (2-3:1)
	Blackgram – barley	
Alfisols and related soils		
150 and above	Sesame – chickpea	
	Blackgram – chickpea	Pigeonpea + blackgram
	Blackgram – mustard	Pigeonpea + groundnut (1:1)
	Mazie – mustard	
Less than 150	Niger – mustard	Maize + blackgram (1:3)
		Maize + okra (1:1)

Sequence cropping

- Rice-lentil/ rapeseed mustard/ chickpea
- Pearl millet - lentil/ rapeseed mustard/ chickpea
- Sesame-lentil / rapeseed mustard/ chickpea
- Blackgram –barely/ rapeseed mustard (If barely or mustard are taken after blackgram in *kharif* 20 kg N/ha can be saved in *rabi*)
- For fodder: Maize + cowpea-oats, pearl millet + cowpea – oats
- Blackgram (T.9)/ sesame in pigeonpea (Bahar NA-1 as base crop (30+90cm)
- Blackgram + pigeonpea (1:2)
- Sesame + pigeonpea (3:4)
- Barley + rapeseed mustard (8:1)
- Lentil + rapeseed mustard (4:1)
- Okra + pigeonpea
- Tomato + linseed

Ballia, Mau, Sitapur, Sultanpur

- Rice-lentil/ mustard/ chickpea for inceptisols having 200-230 water availability period

Farm implements/ tools

Allahabad

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

Ballia, Mau, Sitapur, Sultanpur

- Bullock drawn Malviya multi – farming machine: for field preparation, For seeding dryland crops and fertilizing through mechanical metering device and for intercultivation between two plant rows (particularly *Kharif* season crop) (Rs.2350 per unit)

- Dryland weeder (modified form of weeder supplied by T.N.A.U): For weed control between plant rows of rainfed crops (Rs.70 per unit)

Alternate farming systems

Allahabad

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

Ballia, Mau, Sitapur, Sultanpur

- Agro horti system: Ber + wheat, guava + wheat, guava + pigeonpea, guava + pea
- Fodder/green biomass: *Luecaena leucocephala*, *Azadirachta indica*, *Albizia lebbeck*, *Bauhinia purpurea*, *A. procera*, *B.monosperma*, *A.amara*, *D.sissoo*
- Fruit: Guava, amla, ber, mango bael, jamun.
- Medicinal and aromatic plants: *Papaver somniferum*, *Cymbopogon 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, poultry

Contingent crop planning

Allahabad, Ballia, Mau, Sitapur, Sultanpur

Normal season

- *Kharif*
 - Rice: NDR-97, NDR-118, Govind, Vandana
 - Maize: Ganga safed 2, Knachan, Jaunpuri
 - Pearl millet: 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, Pant L- 639, L 4076, K 75
 - Wheat: HUW-533, K-8027, C-306
 - Barley: DL3, Jyoti, K125
 - Rapeseed mustard: Varuna, Vardhan, Sanjukta, Kranthi
 - 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 and low lands. Uplands should be considered for pigeonpea based intercrop. If rains are delayed beyond the period but start some where in the first to second week of August and growing season is reduced to 60-70 days, then the cultivation of hybrid pearl millet (BJ560, BJ.104), blackgram (T9), greengram (Jagriti, Jyoti) should be taken up. Pulse based intercropping is also recommended. Yet another alternative could be to harvest a fodder of either sorghum, pearl millet, 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, pearl millet, and cowpea for fodder could be harvested. If the rain stops very early, i.e. by the end of August or first week of September, only fodder crops and grain legumes could be harvested. Later on as a mid-season correction sunflower could be planted as it could be sown any time in the year.
- **In extreme drought conditions**
 - Only short duration crops like grain legumes (black and greengram) should be grown
 - Among cereals, (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 late season drought coinciding with reproductive phase of upland rice is frequently experienced (3/7years). If period of drought approaches 8-10 days, 25% yield could be compensated by one life saving irrigation (5 cm depth)

District	Region
Azamgarh Faizabad Kheri Pratapgarh	High runoff and Medium yield gap

Agro-ecological setting

Azamgarh

- **Climate:** Hot dry / moist subhumid
- **Physiography:** Aradh plains (Northern plains)
- **Soils:** Deep loamy alluvium derived soils, deep loamy alluvium - derived soils (Inceptisols – 100%)
- **Annual rainfall:** 1048 mm
- **Potential evapotranspiration:** 1505 mm
- **Moisture availability period:** 150-210 days

Faizabad

- **Climate:** Hot dry / moist sub humid
- **Physiography:** Aradh plains (Northern plains)
- **Soils:** Deep loamy alluvium derived soils, deep loamy to clayey tarai soils (Inceptisols – 100%)
- **Annual rainfall:** 1132 mm
- **Potential evapotranspiration:** 1370 mm
- **Moisture availability period:** 150-210 days

Kheri

- **Climate:** Hot dry / moist sub humid
- **Physiography:** North plains, foot hills of Himalayas
- **Soils:** Deep loamy alluvium derived soils, deep loamy to clayey tarai soils (Inceptisols – 100%)
- **Annual rainfall:** 1132 mm
- **Potential evapotranspiration:** 1370 mm
- **Moisture availability period:** 150-210 days

Pratapgarh

- **Climate:** Hot moist semi arid
- **Physiography:** Aradh plains (Northern plains)
- **Soils:** Deep loamy alluvium - derived soils (Inceptisols – 100%)
- **Annual rainfall:** 1035 mm
- **Potential evapotranspiration:** 1524 mm
- **Moisture availability period:** 120-150 days

Soil and water conservation

Azamgarh, Faizabad, Kheri, Pratapgarh

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

Crop management

Azamgarh, Faizabad, Kheri, Pratapgarh

- **Varieties:** NDR-97, NDR-118, Govind, Vandana, Baranideep
- **Seed rate:** 100 kg/ha
- **Planting pattern:** 30 cm rows and thick intra rows
- **Nutrient management**
 - 80 kg N + 40 kg P₂O₅ + 30 kg K₂O/ha.

- During *kharif* place N basal in seed furrows and remaining top dress when surface is moist (30 to 40 days after seeding). In *rabi* place fertilizer 10-15 cm deep in the seed furrows
- **Pest management:** Keep upland rice fields weed free for the first 30 to 40 days followed by either mechanical or chemical control measures.

Mechanical:

Time of operation	Implement/tool	Remarks
10-40 days after sowing	Hand weeding or mechanical with sweep hoe/dryland weeder	Keep the field free of weeds in the first 40 days. Work 2 to 3 times

Chemical:

Herbicide	Litres/ha	Mode of application
Butachlor + 2,4-D	2,4.0+0.5	Pre-emergence + 30 DAS

Integrated weed management

Chemical	Mechanical	Remarks
Butachlor @ 4 to 7/ha as pre-emergence	One interculture by dry land weeder 30 Days after sowing	Keep the field free of weeds in the first 4 days. Work 2 to 3 times
Pendimethalin 3 l/ha as PE	-do-	-do-

- Stem borer: Dusting of Furodon @ 15-16 Kg/ha 30 days after sowing is recommended
- Gundhi bugs: Dusting of 10% BHC @ 15 kg/ha at the time of heading
- Army worms: Apply Folidol @ 15-20 kg/ha at heading stage (after sunset)
- Blight disease: Spray mixture of 75 g Agrimycin + 2 kg Diathane Z-78 and 1 l Thiodon dissolved in 100 l of water in one ha.
- **Some other important practices**
 - Line sowing
 - Sow upland rice after monsoon sets in and when 15-20 cm soil layer is wet

Suitable Cropping systems

Azamgarh, Faizabad, Kheri, Pratapgarh

- Rice – Chickpea/ Lentil

Alternate farming systems

Azamgarh, Faizabad, Kheri, Pratapgarh

- Agro horti system: Guava + maize
- Fodder/green biomass: *Leucaena leucocephala*, *Azadirachta indica*, *Albizia lebbbeck*, *Bauhinia purpurea*, *A. procera*, *B.monosperma*, *A.amara*, *D.sissoo*.
- Fruit: Guava, amla, ber, mango, bael, jamun.
- Medicinal and aromatic plants: *Papaver somniferum*, *Cymbopogan flexuosus*, *Prosalea*, *Palma rosa*, *Vetiveria zyzanoides*.
- Vegetables: Bottle gourd, brinjal, chillies, cluster bean, cowpea, round melon.
- Animal component: Female and male cattle, female buffaloes.

Contingent crop planning

Azamgarh, Faizabad, Kheri, Pratapgarh

Normal season

- *Kharif*
 - Rice: N-97, N-118, Baranideep
 - Maize: Jaunpuri, Tipakhiya
 - Sorghum: PKV-400, Varsha
 - Pearlmillet: Manupur, WCC-75
 - Pigeonpea: UPAS-120, Bahar
 - Blackgram: T-9, Narendra Urd-1
 - Greengram: Pant Moong-54, Narendra Moong-1
- *Rabi*
 - Chickpea: Avrodhi, T-3
 - Lentil: NDL-2, DPL-15
 - Rapeseed mustard: Vibhav, Varuna
 - Linseed: Garima, Sweta
 - Wheat: Atal, C-306, K-8027
 - Barley: Lakhan, Narendra Jau-4
 - Compatible genotypes for cropping system
- Sequence - Rice – Lentil NDR-97 – NDL-1
- Intercropping – Linseed + chickpea (Sweta + Avrodhi)

Aberrant weather

Normal onset of monsoon followed by long gaps in rainfall

- In case of very early break in monsoon i.e. 7-10 days after seeding and if seedling are killed resow with the same variety.
- Gap filling/ transplanting in case of cereals like uplands rice and pearlmillet 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 N/ha. For this purpose community nurseries of emergency nurseries should be kept ready.

Delayed onset of monsoon

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

Early stoppage of rains towards the end of season

- Normal sowing of short duration *kharif* crops such as upland rice (N-97, Mutmuri), blackgram (T-9), 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.

- Depending on the soil moisture condition, relay sowing of *rabi* crops such as chickpea, lentil, linseed and barley could be done in the *rabi* season.
- **In extreme drought conditions**
 - Only short duration crops like grain legumes (black and greengram) should be grown.
 - Among cereals, maize (Tipekhiya) gave a fair performance
 - Intercropping maize in inter rows of pigeonpea was found successful
 - Rice crop, if already sown is not likely to succeed, may be ploughed under to conserve moisture in the soil.

SUMMARY

There are two main seasons for growing rainfed rice in India. The *kharif* season is characterized by a gradual fall in temperature, more numerous cloudy days, low light intensity, gradual shortening of the photoperiod, high relative humidity and cyclonic weather. During *Rabi*, there is a gradual rise in temperature, bright sunshine, near absence. Upland rice is normally grown in rainfed, well-drained soil in sloppy, undulating or terraced land, without surface water accumulation. The depth of the water table is below two meters. The soil is shallow in depth with low water holding capacity with red, acidic soils predominating.

Farmers grow traditional rice usually without fertilizer inputs or with low inputs. They weed the crop once based on crop growth and availability of labour. The yield is about 0.5-0.8 t/ha of rough rice. To ameliorate these constraints, the Central Rainfed Upland Rice Research Station (CRURRS), Hazaribag, a Research Station of the Central Rice Research Institute (CRRI), Indian Council of Agricultural Research, Cuttack, has been working on the improvement of upland rice. The research station has developed a technology that ensures an average yield of 2-3 t/ha of rice. As yields are dependent on a number of factors, it is necessary to follow a comprehensive crop management strategy comprising of varietal selection, crop establishment, nutrient (fertilizer) management and pest management. Efforts can also be made to increase the cropping intensity by growing rice intercropped with pigeonpea with slight variation in the crop management strategy.

Monocropping is the practice of the farmers in banded and unbanded uplands and part of medium land. However, growing more than one crop per annum either using pre-monsoon showers, in post-monsoon period on retained moisture, or using irrigation from shallow wells is a practice with the farmers on the semi-deep, intermediate, shallow lowlands and adjacent parts of medium land.

The area and yield growth rates of each district were calculated. The rates, which are not statistically significant, are treated as stagnant and others were decided based on the sign, positive or negative. The area stagnant and yield stagnant zones show the traditional area of the crop. The area increasing and yield increasing signify the effect of market. The area decrease mostly coincides with replacement by other commercial crops. Yield decreasing may be due to persistent pests and disease attack or continued land degradation through mostly nutrient mining. Yield increasing mostly coincide with high technology adoption like new cultivars.

The prioritized causes of low yields in direct sown rice are - weeds, low and uneven plant stands, soil compaction and use of unsuitable cultivars, yield reduction due to drought, wild rice, low soil fertility and stem borers. The farmers expressed that their practices loosens soil, control weeds, optimize plant stand stimulate root growth, and overall, improve rice yields under low cash input conditions (Fujisaka et al. 1983). Varieties were identified for intermediate deepwater situation (Ghose & Reddy 1984), drought prone areas (Swami et. al. 1998) and other environments (Mishra 1999).

Suitable intercropping systems for mitigating drought were identified (Pradhan and Subudhi 1996). Mixed/inter cropping with minor millets or pigeonpea (*Cajanus cajan*) was attempted for increasing total output as well as income of the farmers. Practically no possibility of growing two crops without irrigation from harvested surface runoff in ponds. These lands are more suitable for finger millet (*Eleusine coracana*) little millet (*Panicum milliare*), maize (*Zea mays*), groundnut (*Arachis hypogea*), blackgram (*Vigna radiata*) etc. Run-off and soil loss was reduced significantly from uplands by improved cropping systems (Subudhi and Senapati 1995, Subudhi et al. 1995).

With groundwater not beyond one m deep in shallow wells, the medium lands are irrigated and are most productive owing to good water management. High yielding varieties are most responsive to added inputs. The need of irrigation was of the order of only 10% under rainfall exceeding 1500 mm per annum to rainy season rice. A shallow submergence (5 - 7cm) as above saves 15 to 20% water compared to traditional practices by imposing the submergence from 1 to 3 days after disappearance of ponded water. In large areas, 2 to 3 crops can be grown with water saving techniques.

Jute before Rice: In the lowland double cropping is practiced with jute preceding rice. Jute is a pre-rainy season commercial fiber crop. Sowing starts with Northwester rain, followed by rainy season rice under rainfed condition. Jute cultivation is mostly confined to the eastern parts of Bihar, Orissa and Uttar Pradesh.

On the other hand, no other suitable crop can substitute economically better than jute in pre-rainy season. To produce better quality fibre, availability of natural slow flowing water for retting is a must. Jute can be further upgraded in the districts of Pratapgarh and Bahraich in Uttar Pradesh; Katihar and Purnea in Bihar; and Kendrapara in Orissa.

Relay Cropping: Rice based relay (*utera/paira*) cropping is a most common practice under rainfed agro-ecosystem in medium to intermediate lowlands of Madhya Pradesh, Jharkhand, Chhattisgarh and Orissa. This is a mode of seeding suitable for post-monsoon cropping by broadcast about 2-3 weeks before harvesting of rice. Thus, a second crop in succession to rice is grown by utilizing the advantage of residual soil moisture left in rice fields without tilling the land and usage of fertilizers. Any one or two of the several pulse or oilseed crops (linseed, lathyrus, blackgram, greengram, chickpea, lentil etc., in Bihar and Uttar Pradesh) are the choice of farmers according to their socio-economical status. Establishment of rainfed intercrop or *paira* crops under stubbles was efficient (Das and Das 1994, Agarwal 1982).

Different rice based relay cropping systems have been found successful in increasing the cropping intensity and improving the productivity of the cropping system (Kosta et al. 1988, Singh and Singh, 1995, Mahto et al. 1996, Das and Bhanja 1996, Dwivedi et al. 1997 and Sharma and Yasin, 1997). Seeding of other crops in standing rice crop between milk or dough stage, the residual soil moisture will be minimized, which would result in increasing the productivity of crops and cropping intensity (Singh et al. 1993, Das and Bhanja, 1996 and Sharma and Yasin, 1997). Proper nutrient management (Singh et al. 1993 and Dwivedi et al. 1997) and weed management (Kosta et al. 1988, and Mahto et al. 1986) are reported to be useful for increasing the productivity of crops. Implements have been developed for seed placement etc., which are not popular with farmers.

Generally relay crops are grown without attention just to grow a second crop after rice crop due to the problem of uncontrolled grazing by stray animals. The low productivity of rice-rice in monocropping or low productivity of both crops in rice based system result into the under use of residual soil moisture, agricultural labourers etc., available in these areas. The socio economic status of the farmers in this area does not permit them to adopt the improved production technologies developed by the agricultural scientists to step-up the productivity of rice also. They do not follow the suggested practice of double cropping systems for rainfed conditions. The agricultural labourers become surplus after the harvest of rice in these areas and they migrate elsewhere in search of the employment. Pulse or oilseed crops after rice through relay cropping would be advantageous for improving the socio economic status of the farmers (Singh et. al. 1999).

Intercrops with Rainfed Upland Rice: Upland rice is generally monocropped in well-drained soil in sloppy, undulating or terraced lands. The cropping intensity is very low as farmers take only one crop of rice. Efforts are being made at the Central Rainfed Upland Rice Research Station (CRURRS), Hazaribag, to evolve suitable cropping systems and increase the cropping intensity in these areas. Few farmers grow crop mixtures of rice and pigeonpea or pigeonpea and maize producing very low yields due to improper ratios of crop mixtures and poor crop management practices. Results of trials conducted during the last decade at CRURRS, Hazaribag, revealed that system approach to cropping can ensure stable optimal yields and maximum profit to the upland rice farmers. Farmers on a particular parcel of land by whole village grow upland rice or pulse millet. Niger is grown late in the season for their oil requirement, sometimes as a contingency crop when monsoon fails to arrive at normal time and chances of rice cultivation appears meager. As lands are fragmented selection of crop for a particular parcel is done on a community basis. If one-year rice is grown by whole village on a particular land area, another year a different crop is cultivated or left fallow for grazing by cattle belonging to the village. A few farmers are cultivating tomato and cauliflower fetching good price during the rainy season. Studies conducted at CRURRS, Hazaribag revealed that intercropping is the best option for crop diversification in red soils of rainfed upland rice areas. Research conducted in red soils revealed that upland rice can be successfully intercropped with pigeonpea if both crops are line sown in 4:1 row ratio with inter-row spacing of 20 cm. Rice + pigeonpea intercropping gave higher returns than relay or sequence cropping of either niger, toria or horsegram with rice. Among the several intercropping systems evaluated, rice + pigeonpea was the most advantageous. Though highest gross returns were obtained with rice + groundnut (2:1), higher cost of cultivation placed it second in terms of net monetary benefits. It was followed by rice + finger millet (2:2). Grow pigeonpea as mixed cropping with upland rice. The ratio should be four rows of rice and one row of pigeonpea. Use pigeonpea variety

UPAS 120 in Orissa and BR 65 in Jharkhand for mixed cropping. Grow horsegram (kulthi) after harvest of upland rice to improve soil fertility following practices may be followed for intercropping.

- Field should be ploughed once with mould board and twice with country plough and, if possible, once with disc harrow to get a fine tilth. To ensure better germination and crop stand land should be leveled with a ladder during final land preparation.
- Upland rice varieties of intermediate stature and 85-100 days duration are most suitable for rice based intercropping systems. Most popular varieties in this group are Vandana and Kalinga III. Pigeonpea varieties suitable for intercropping include UPAS 120 and BR 65. Insect pest problem is less in UPAS 120 and BR 65. Groundnut varieties like BG 3 and BAU 6 are suitable for intercropping with upland rice and have less incidence of "tikka" disease when intercropped in paired rows with 4 rows of rice.
- Use mechanically separated seeds (MSS). Mechanical seed separation is done to eliminate lighter, disease infected (sheath rot, blast), and unhealthy seeds under the existing seed system of subsistence farming (storing winnowed grains for seed for the next year by individual farmers). MSS provides physiologically similar seeds that give uniformly better crop stand, and synchronous flowering. This results in higher efficacy of contact pesticides such as Endosulphan, and also leads to synchronous grain maturity. MSS should be done, if required, before any chemical seed treatment. Avoid seed treatment in case of certified, and treated seeds.
- MSS Procedure: Should be done during hot summer months (April/ May) under sunny days.
 - Dissolve common salt (not iodized salt) in water @ 200g/ liter. Dip seeds in the salt solution. Stir wooden/ bamboo peg for a minute and allow it to settle for one minute. At a time, 10 liters of solution is sufficient for treating 5 kg of seed. The same solution can be used three to four times (15-20 kg seed) depending on cleanliness of the seed.
 - Separate and reject floating seeds.
 - Wash the remaining seeds twice with water, and sundry for at least two days.
- Lime is required for lowering soil acidity in uplands. Mix lime *in-situ* @ 500 kg/ha in semi-wet soil 20 days before seeding for higher yield of upland rice. For optimum yield of pigeonpea, apply 2,000 kg lime mixed in soil 20 days before sowing.
- Second fortnight of June is the appropriate time for sowing rice and intercrops. During second to third week of June. And to be completed latest by the last week of June. Dry seeding should be done in case of delayed monsoon.
- Farmers generally broadcast both rice and pigeonpea in mixed cropping. Research indicated that if rice is broadcast and pigeonpea planted in rows 75 cm apart, this system gives more returns than pigeonpea broadcast in line sown rice crop. If both crops are sown in rows, a uniform distance of 20 cm between rows should be maintained and row ratio of rice and pigeonpea should be maintained at 4:1.
- To be done behind bullock drawn country plough at a depth of 4 to 6 cm, and 20 to 25 cm apart followed by laddering.
- In intercropping system sow rice + pigeonpea in 4: 1, with row-to-row spacing of 20 cm.
- A seed rate of 100 kg/ha is adequate when the crop is sown behind the plough (shallow depth of seed placement) in moist soil.
- Remove excess seedlings from hills and fill the gap only at the time of drizzling.
- Lime may be applied in red acid soils @ 0.5 t/ha in furrows where pigeonpea is to be planted. Before application in furrows lime may be mixed with wet soil in 1:1 ratio. It would help avoiding direct contact of lime to seed. Use of lime should be restricted to pigeonpea alone. Application of lime to pigeonpea is likely to benefit rice crop in the long run because of leaf shedding through profuse growth of pigeonpea. If farmers are growing groundnut or blackgram, in association with rice, application of lime is not needed as no beneficial effects were marked in these crops.

- Nitrogen should be band placed in pigeonpea furrows at seeding @ 20 kg N/ha. Phosphorus and potash may be applied basally @ 30 Kg P₂O₅ and 20 kg K₂O/ha for rice and the intercrop. Rice should be top dressed with 40 kg N/ha in splits at 20 and 40 days after sowing (DAS) after removal of weeds. Give entire dose of P after incubation with farmyard manure, and K as basal in seed furrow before seeding. Apply N in three splits-20 kg/ha after first weeding 20 days after seeding, 10 kg/ha at 35 to 40 days after seeding and after second weeding, and the remaining 10 kg/ha at booting stage.
- Weeds may be manually removed twice at 20 and 40 DAS. Weeds may be chemically controlled by applying pendimethalin @ 1.0 kg a.i./ha 1-2 days after emergence of pigeonpea/ groundnut crop and supplemented with single hand weeding at 25 DAS.
- Needed based application of pesticides must be done in pigeonpea and groundnut crop. Termites and gundhi bug are major insect pests of upland rice that cause substantial losses in yield. Endosulphan 35 EC @ 1.2 ml/litre of water should be applied at milk stage of rice to control gundhi bug. To take care of termites seed should be treated with chlorpyrifos @ 700 g a.i./100 kg of seed. Pest control is generally not required for pigeonpea, however, if pod borer infestation is high, endosulphan 35 EC @ 2 ml/l may be sprayed at flowering; groundnut may be protected with Dithane M 45 @ 2.5 g/l against 'tikka'.
- Rice crop should be harvested 30 days after 50% flowering. Pigeonpea variety UPAS 120 matures in 5 months; BR 65 in six and half months. Pick the pods 2-3 times in pigeonpea to avoid shattering. Groundnut crop may be harvested when the leaf colour turns yellow.

Sequence Cropping: The traditional practice of harvesting ear heads in transplanted rice would not allow a second crop in spite of the extended monsoon and increased/extended soil moisture availability. Crops after rice are grown in places where rainfall is well distributed and exceeds 1000 mm per annum in parts of medium and lowland. This can be adopted without any supplemental irrigation if rice variety not exceeding 125 days duration is grown during monsoon season. Soil retains moisture within the rooting zone of the second crop (crop after rice) at least for a period of about two months after termination of rains. Appropriate soil moisture conservation practices like minimum tillage, mulching, etc., are adapted. Short duration, drought tolerant and/or deep rooting crops are selected and grown after rice. Land preparation in rice fallow is a real challenge under decreasing soil moisture status. Moisture is adequate in sub-soil but seed zone is dry.

Cropping after harvest of rice with groundnut, rapeseed mustard, sesame, niger, lentil, linseed etc., (Dwivedi et. al. 1997, Singh et. al. 1993, Mahto et. al. 1996) is also practiced in Orissa and other eastern states. However, rice fallow is common due to difficulties associated with tillage after rice and good seedbed preparation. Another important issue is the establishment of the second crop, immediately after the harvest of rice. The Indira Gandhi Krishi Vishwa Vidyalaya, Raipur has shown a possibility of providing a come up irrigation from harvested water for establishing a good second crop from harvested water.

Integration by Diversification: In such lowlands of medium deep and semi-deep water ecology (30-100 cm), fish can be grown along with rice, and certain conditions necessary for fish culture have to be provided (Huet 1973; Van Dyke and Green 1974). Aquatic environment has pH 6.8 to 7.8, temperature 25 to 35° C and the dissolved oxygen content 3 to 9 pm, which is favourable for rearing of fish. For maintaining sufficient depth of water and shelter for fish during prolonged non-rain period, the lowland field, however, requires a special arrangement.

Rice-fish system technology is applicable to medium and large groups of farmers. Farm area from one acre to one hectare is suitable. This system integrates different compatible components like improved rice, fish, prawn and different crop after rice in the main field and vegetables and fruit crops on bunds besides ducks, poultry, pigs, etc. The synergistic effect of rice and fish leads to increase in grain yield by 5 to 15%. It promotes gainful linkage between the rice, fish, vegetables and the horticulture enterprises resulting in a better resource utilization and conservation of ecosystem. Moreover, such a farming practice generates more than 200 additional man-days employment year-round and benefit cost ratio is 1.3. This system can provide more than fifteen times higher productivity (16.6 t/ha) over traditional rice farming. This rice-fish farming technology was acceptable to some farmers of Orissa, Jharkhand and Bihar. This technology facilitate cost effective land, water and other resources use by way of diversified farming due to creation

of a micro-watershed within the system.

Rice-fish integration helps in enrichment of soil organic matter and nutrient. Reduced nutrient loss in rice field due to introduction of fish and effective utilization of weeds, plankton, macro and micro aquatic animals, insects, bacteria and organic detritus through introduction of herbivorous and omnivorous fishes give additional benefit in terms of productivity since material and energy are converted into fish production (Ali, 1990, Sinha Babu, 1997). The shallow lowlands mostly suit to fish seed of fry-fingerlings size rearing, while others provide scope for marketable fish farming.

Olericulture (Behera et. al. 1998), vegetables as intercrops (Behera 1996), turmeric (Mohanty et. al. 1997) etc., were also finding place in the changing scenario. (Ali, 1990, ICAR, 1996, Fedork & Neela Patra 1992).

Integrated Pest Management

Upland rice is grown in rainfed, unfavorable soil and weather conditions. Out of 6.5 m ha under upland rice in India, 80% is grown in Eastern India. Weeds constitute the most economically important constraint accounting for about 20% loss in grain yield. Other pests (insects and diseases together) account for about 15-20% additional losses. Some of the weeds, insect and disease pests are more critical to specific areas and soil types than others.

Weeds: Aerobic soil environment and optimum temperature in upland soils encourage growth of grassy weeds (*Echinochloa solona* (L) Link., *E. crus-galli*, Beau., *Eleusine indica* (L) Gaertn., *cynodon dactylon* (L) Pers., *Digitaria ciliaris* (Retz) Koel., *Dactyloctenium aegyptium* (L), *Setaria glauca* Roem and Schult);

Specific sedges (*Cyperus rotundus* L., *C. iria* L.) and broad leaved weeds (*Ageratum conyzoides* L., *Acanthospermum hispidum* DC., *Amaranthus viridis.*, *Cleome viscosa* L., *Euphorbia hirta* L., *Phyllanthus niruri* L.) Weeds also germinate along with rice plants and compete for light, moisture, nutrients and space.

- *Under monocropping of rice:* Give early post-emergence application (1-2 days after emergence (DAE) under moist soil condition) of Butachlor (1.5 kg ai/ha) or Anilophos (0.5 kg ai/ha) or Thiobencarb (1.5 kg ai/ha) or Pendimethalin (1 kg ai/ha) followed by one hand weeding after 25-30 DAE.
- *Intercropping system of rice + pigeonpea:* Give early post-emergence application of Pendimethalin (1 kg ai/ha) followed by hand weeding.

Insects: Termites (*Odontotermes obesus* and *Microtermes obesi*) are the most important insect pests that cause considerable damage to upland rice. Termite infestation is more in red and lateritic soils with light texture and low water holding capacity. Termites attack the root portion; gradually the shoots turn yellow and dry up. As a result the plant population in the field is reduced. The nymphs and adults of the rice stink bugs (gundhi bugs) *Leptocoris oratorius* and *L. acuta* feed on the milk of developing grains at early stage rendering them chaffy. A diffused brown spot is caused by the exudation of sap at the point of insertion causing an off flavour to not only partially damaged grain even after cooking but also to the straw rendering it unattractive to cattle. Other insects occur only sporadically.

In Dhenkanal (Orissa) termite, gundhibug and yellow stem borer are important insect pests in this ecology. Seed treatment with chorpriphos @ 0.5 kg/100 kg seeds at the time of sowing proved effective for controlling termites. Similarly, gundhi bugs were effectively controlled by spraying of Monocrotophos @ 0.5 kg a.i./ha at flowering when 1-2 bugs/ m² were observed (Jha et al 1995 & 1998). Among the diseases blast (foliar and neck blast) was serious problem which was controlled by the application of Hinosan 50 Ec @ 1 ml/l. Among the varieties, Sneha and Kalinga III were more affected by neck blast at post flowering stage. Brown spot was of minor importance but was more serious in local varieties. Vandana showed 0 reaction to both the diseases in 0-9 scale.

Diseases: Brown spot caused by *Bipolaris oryzae* (Breda de Haan) Shoemaker, occurs when rice is grown in poor soils under prolonged drought spells. Deficiency and imbalance of phosphorus, potash and certain micronutrients influence brown spot intensity. Blast (*Pyricularia grisea* Sacc.), on the other hand,

causes significant yield by better nutrient management. The plateaus and hills are especially prone to leaf and neck blast. Sheath rot (*Sarocladium oryzae*) is another disease, causing lesions on sheath commonly noticed in upland rice with lower intensity.

Sheath Rot: Use mechanically separated seeds. **Brown Spot:** Need based application of Dithane M 45 (Mancozeb) @ 0.12% at action threshold level (ATL) 8-10% leaf infection.

Neck Blast: Need based application of Hinosan 50 EC (Ediphenphos) @0.1% at ATL 8-10% neck infection or Kitagin 17G granules @25 Kg/ha.

Historically, pest control strategies have progressed along lines of pest type (weed, insect, disease) separately. Approaches addressing pest activity as a whole has been initiated using mono or dual control tactics. Recently, the pace has quickened to develop multi-tactic approach of pest control. More recently, three conditions associated with pest control are altering the perspective of pest control technology. The first is the environmental impact of indiscriminate use of plant protection chemicals. Second is the introduction of management concept as opposed to *control* which meant eradication of a certain pest. Management refers to reduction of pest population below a certain level not harmful to crop to maintain the ecological equilibrium. Thus the three areas i.e. environment, management and ecological considerations have been fused together into a new pest control technology called integrated of technology but developing awareness among the farmers.

Based on the information available, an Integrated Pest Management strategy for rainfed upland rice have been developed and validated through on-farm trails by the Central Rainfed Upland Rice Research Station.

Unlike other ecosystems of irrigated rice, upland rice has not witnessed any over-use of pesticides at least in India, which originally spurred Integrated Pest Management activities. Not only that, traditional management has some elements of being integrated. While formulating IPM strategies for rainfed upland rice, the practices with multiple benefits were considered first. The following points are important in this context.

- Selection of variety with 90-100 days duration, moderate resistance to blast and field resistance to brown spot like "Vandana"
- Use of healthy seeds (mechanically separated seeds using 20% common salt solution) – this manages sheath rot in varieties of 90-100 days duration.
- Sowing crop (line sowing) latest by June last week
- Use of high seed rate of 125 kg/ha
- Split application of N fertilizer: (10 kg N (22 kg urea) basal + 20 kg N (44 kg urea) at 30 days after emergence (DAE) + 10kg N (22 kg urea at 45 DAE).
- Early post emergence (1-2 days after germination) application of butachlor (weedicide) @ 1.5 kg a.i./ha (Machete 50 EC 31/ha) under moist soil condition. This is to be followed by one hand weeding 25-30 days after germination.
- Need based application of carbofuran @ 1 kg a.i. /ha (Furadan 3G @ 33kg /ha) 20-25 days after germination under drought situation to reduce termite damage.
- Need based application of endosulfan @ 0.5 kg a.i./ha (Endosulfan 35 EC 1.2 l/ha) for stem borer and stink bugs (gundhi bugs)
- Need based application of mancozeb (Dithane M 45 @ 1.2 kg/ha) for brown spot at action threshold level (ATL) of 8-10% leaf infection.
- Need based application of ediphenphos @ 0.5 kg a.i./ha (Hinosan 50 EC @ 1 l/ha) under drought condition for managing neck blast at ATL of 8-10% neck infestation.

Traditional farming practices and systems are often abandoned in an effort to increase productivity and income often ignoring the sustainable crop protection practices that have evolved among farmers to cope with the environmental stresses under which upland rice is grown. Crop rotations, diversification, organic amendments and adjustments of crop establishment time, geometry and density profoundly influence pathogen and insect populations. Integrated Pest Management is therefore strongly linked to and integrated of insects, diseases and weeds in upland rice.

Harvesting

Harvest the crop 30 to 35 days after flowering. Thresh the crop immediately after harvest.

Drying and Milling

Sun dry the harvested rice upto 12% moisture content for seed purpose and 14% for milling.

For rainfed uplands of Kalahandi (Orissa) intercropping of rice with arhar (pigeonpea) in 4:1 ratio was found more remunerative and sustainable. This inter-cropping gave a net return of Rs.6,010/ha compared to Rs.3,886/ha from sole rice and Rs.5,937/ha from sole arhar. Among different cropping systems tested under rainfed upland, rice tomato was found most profitable (Rs14,693/ha) and this return was higher than the traditional rice-horse gram (Rs4,750/ha) system.

Varieties/ Hybrids Released during 1996 – 2002

The information on varieties/ hybrids released during 1996-2002 from the Annual Report(s), Department of Agricultural Research and Education, Ministry of Agriculture, Government of India, and Indian Council of Agriculture Research, New Delhi are summarized below. Apart from the rainfed region, information is also included on dry irrigated regions. This information may be read in conjunction with the recommendation of the centers for rainfed rice. Following are cultivars released for rainfed upland, medium to low land and deep water rice growing regions.

Cultivar	Recommended region	Salient features (Year of release)
Upland		
Lalithagiri	Orissa	Medium bold, 3.2-6.7 t/ha, maturity 90-95 days (1999 – 2000)
Danteshwari	Direct-seeded uplands of Madhya Pradesh	Grain Long slender, Moderately resistant to Blast (2001 – 2002)
KHP 5	Direct-sowing situation of hill zone of Karnataka	Grain Medium bold, Moderately resistant to Blast (2001 – 2002)
Bhagdh dhan	Rajasthan	Long bold, 4-5 t/ha, maturity 90-100 days (1999 – 2000)
Medium to low land		
Krishnahamsa	Jharkhand and Bihar	Grain Long slender, Resistant to Blast, cold (2001 – 2002)
Jawahar 3 –45	Madhya Pradesh, Uttar Pradesh, Chattisgarh and Orissa	(1997-98)
Shyamla	Madhya Pradesh, Chattisgarh	(1996 –97)
Pooja	Madhya Pradesh, Chattisgarh, Orissa	Medium bold, 4-5 t/ha, maturity 150-155 days, Gallmidge tolerant (1999-2000)
Mahanadi, Indravati, Prachi, Ramchandi	Orissa	Medium bold, 4.2-6 t/ha, maturity 150 – 155 days (1999 – 2000)
PMK 2, TPS 3, Poornima, CORH 1	Tamil Nadu	(1996 –97)
Hemavati Durga	With temporary sub-mergence problem in hill zone of Karnataka	Grain Medium slender, Resistant to Blast (2001 – 2002)
Rashmi: IET 13832: JR 201	Madhya Pradesh	IR 36/JR 75, Semi-dwarf; maturity 105 days; long slender grains; resistant to blast and gallmidge biotype 1. (2001)
Dhala Heera: IET 11411: CR 544-1-2-4	Orissa	CR 404-48/ CR 289-1208; Semi-dwarf; maturity 80 days; long bold grains; 2.5 t/ha grain yield; resistant to sheath blight, sheath rot and brown planthopper; also suitable for post flood situation. (1997)

Cultivar	Recommended region	Salient features (Year of release)
Heera: IET10973: CR 544-1-2	Orissa	CR 404-48/CR 289-1208; Semi-dwarf; maturity 65 days; long bold grains; brown hull; resistant to blast, rice tungro virus and gall midge; Also suitable for post flood situation (1997)
Lalitagiri: IET 13198: OR 1045-1-3	Orissa	Badami/IR 19661-364; Semi-dwarf; maturity 90-95 days; bold grains; resistant to blast, brown spot, gall midge and brown plant hopper. (1999)
Udayagiri: IET 12136: OR 752-38-1	Orissa	IRAT 138/ IR 13543-66; Tall; maturity 90 days; long slender grains; resistant to blast and tungro virus. (1999)
Deep water		
Neeraja	Uttar Pradesh (up to 1 m depth)	Grains long slender, maturity 180 days, tolerant to sheath blight, sheath rot and blast (1998 -99)

It can be summarized that moisture stress is the foremost limiting factor in upland areas. Seeding is generally done in these areas after the onset of monsoon that leave some amount of rainfall unutilized and sometimes results in delayed planting due to continuous rains. Experimental evidences showed substantial increase in productivity with a fortnight advancement in seeding date. Manipulation of seeding depth ensured optimum plant population. Seeding in rows 20 cm apart proved the best method of stand establishment. Other methods tested {broadcast, single rows 14,20,25,30 cm apart, paired and triple rows 10 cm apart with an interspace of 30 cm (10/30 cm),} affected the plant growth significantly but failed to influence yield. Crop sown by broadcast method suffered more from lodging than row seeded crop. Under good management, optimum seed rates for row seeding and broadcasting were 300 and 400 seeds/ m² (67.5 and 90 kg/ha for test variety 'Kalinga III'), respectively. The Weeds also limit the productivity of upland rice and if left uncontrolled reduces productivity upto 76.9%. Most critical period for crop-weed competition was first 30 days period. Application of butachlor/ pendimethalin supplemented with single hand weeding at 25-30 days controlled weeds effectively and produced yields similar to 2 hand weedings, when applied 3-4 days at 1.5 and 1.0 kg a.i., /ha, respectively. Although use of increased seed rate (600 seeds/ m²) reduced weed dry matter accumulation, impact could not be reflected in terms of grain yield. Predominant weed spp. an *Echinochloa colona*, *Ageratum conyzoides*, *Commelina bengalensis*, *Paspalum dilatatum*, *Celosia argentia*, *Brachiaria remosa*, *Eleusine indica*, *Cyperus rotundus* and *Fimbristylis litoralis*. N-use efficiency is very low in rainfed uplands areas. N use efficiency in rainfed upland rice could be increased using POC urea (polyolefin resin coated urea), also known as controlled release urea. General recommended dose of N:P:K was worked out as 40.0:8.67:16.67. However, response of N varied greatly due to varieties and economic optimum N rates for Vandana, Aditya and RR 165-1160 were calculated as 43.0, 50.0, 52.5 kg N/ha, respectively. Response to N at 30 kg N/ha was maximum (27.7 kg grain/ kg of applied N) in RR 165-1160 followed by Aditya and Vandana and at 60 kg/N in Annada (18.4 kg grain/kg of applied N) in RR 165-160 followed by Kalinga III and RR 165-1160. Monoculture of rice leads to gradual decline in productivity as well as soil sickness over a period of time. Agroecomic assessment made on several cropping systems showed that 'Kalinga III' upland rice variety intercropped with 'BR 65', Pigeonpea in 4:1 row ratio was the most advantageous system, with average yield of 0.6 t/ha of rice and 0.6 t/ha of Pigeonpea and a net return of Rs. 4020/ ha (compared with total variable costs) and return of 2.72/Re invested. Further studies made to fine-tune this technology suggested that broadcast of rice seed @ 100 kg/ha in the inter-space of 75 cm between two rows of pigeonpea could be as good as row seeding of both crop in 4:1 row ratio (Jaiswal *et.al.*, 2002)

Some district based prioritized cultural options are –

State	District (Yield gap %)	Prioritized Options	Average yield (t/ha)	Expected yield (t/ha)
Bihar	Champan (East) (74%)	Management of surplus water for second crop	1.0	1.13
Chattisgarh	Bilaspur, Durg, Raigarh, Raipur (63%)	Management of surplus water for second crop	1.3	1.55
	Bastar, Rajnandgaon, Sarguja (74%)		1.0	1.13
Jharkhand	Deogarh (63%)	Management of surplus water for second crop	1.3	1.55
	Giridih, Gumla, Hazaribagh, Ranchi, Singhbhum (West), Singhbhum (East) (74%)		1.0	1.13
Karnataka	Dharwad (65%)	Water harvesting technology for surplus water and subsequent use. High yield cultivars	1.2	1.45
Karnataka	Belgaum (63%)	Management of surplus water for second crop	1.3	1.55
Madhya Pradesh	Damoh, Panna, Rewa, Satna, Sidhi (83%)	Water harvesting technology for surplus water and subsequent use. High yield cultivars	0.6	0.72
	Balaghat, Seoni (63%)	Management of surplus water for second crop	1.3	1.55
Maharashtra	Jabalpur, Mandla, Shahdol (74%)		1.0	1.13
	Pune (65%)	Water harvesting technology for surplus water and subsequent use. High yield cultivars	1.2	1.45
	Bhandara, Chandrapur (63%)	Management of surplus water for second crop	1.3	1.55
Orissa	Kolhapur (28%)	Efficient use of runoff water, improved pest and disease management practices and high yield cultivars	2.5	2.89
	Gadchiroli (74%)	Management of surplus water for second crop	1.0	1.13
	Dhenkanal (45%)	Water harvesting technology for surplus water and subsequent use. High yield cultivars	2.0	2.3
	Balasore, Cuttack, Koraput, Mayurbhanj, Phulbani, Puri, Sambalpur (63%)	Management of surplus water for second crop	1.3	1.55
Uttar Pradesh	Kalahandi, Keonjhar, Sundargarh (74%)		1.0	1.13
	Azamgarh, Fizabad, Kheri, Pratapgarh (45%)	Water harvesting technology for surplus water and subsequent use. High yield cultivars	2.0	2.3
	Allahabad, Ballia, Mau, Sitapur, Sultanpur (53%)	Efficient use of runoff water, improved pest and disease management practices and high yield cultivars	1.7	1.96

POPULAR AND BOTANICAL NAMES OF SOME RAINFED CROPS

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

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

GENERIC AND BRAND NAMES OF SOME PESTICIDES

Herbicides/ Weedicides

Herbicides/ Weedicides

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

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

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

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

BUTACHLOR 50 EC, 5 GR.: Machete (Monsanto), Teer (Rallis), Milchlor (Montari), Wid Kil (Sudarshan Chemicals), Aimchlor (AMICO), Nirmool (Lupin), Starchlor (Shaw Wallace), Dhanuchlor (Dhanuka), Specclor (Southern Pesticides), Hiltaklor (Hindustan Insecticides), Trapp (Searle India), Delchlor (Coromandel Indag), Bilchlor (Bayer)

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

FLUCLORALIN 45%: Basalin (BASF)

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

METALACHLOR 50% EC: Duel (Novartis)

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

OXADIAZON 25% EC: Ronstar (Rhone-Poulenc)

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

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

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

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

Insecticides

ALDICARB: Temic 10 G (Rhone Poulenc)

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

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

CARBOSULPHAN 25% DS: Marshal (Rallis)

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

CYPERMETHRIN 10 EC: Ralothrin (Rallis), Ankush (BASF), Simper (ICI-Zeneca), Hi-Power (Sulphur Mills), Spec Cyperin (Southern Pesticides), Hycyper (Hyderabad Chemicals), Cyper Top (Thakar Chemicals), Lacer (Searle India), Agro-Cyper (Gujarat Agro), Jawa (Dupont), Cypercine (IOCL), Super Killer (Dhanuka), Cypermil (Montari), Polytrin (Novartis), Cyproid (AIMCO), Challenger (Tropical Agro), Cilcord, (De'Nocil), Starcip (Shaw Wallace), Volcyper (Voltas), Cypermar (Parry Chemicals), Hilcyperin (Hindustan Insecticides)

CYPERMETHRIN 25 EC: Cymbush (ICI-Zeneca), Ralothrin (Rallis), Cypersul (Sulphur Mills) Spec Cyperin (SPEC), Angel (Hyderabad Chemicals), Cyper Top (Thakar Chemicals), Trofy 25 EC (Searle India), Cypercine (IOCL), Challenger (Tropical Agro), Cypermil (Montari), Cyperguard (Gharda Chemicals), Polytrin (Novartis), Cyproid

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

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

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

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

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

ENDOSULFAN 35 EC & 4% D, 2% D: Thiodan (Agro Evo), Endocel (Excel), Endosul (Sulphur Mills), Endostar (Shaw 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 (Rhouné – Poulneq), Tempo (Agr Evo)

FORMOTHION 25%: Anthio (Novartis)

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

MALATHION 50 EC: Dhanuka Malathion (Dhanuka), Cythion (Cyanamid Agro), 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), Lumphos (Lupin), Kadett (PesticidesIndia), Agromonark (Gujarat Agro), Moncar (Bhaskar Agro), Azodrin (Cyanamid Inida), Hilcron (Hindustan Insecticides), Macrofos (Tropical Agro), Croton (Searle India), Balwan (Rallis), Monophos (Parry Chemicals), Monocron (NFCL), Corophos (Coromandel Indag), Bilphos (Bayer), Monosect (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 India), Volphor (Volrho), Starphor (Shaw Wallace), Specphor (SPEC), Forcin (IOCL), Dhan 100 (Dhanuka), Milate (Montari), Granutox (AIMCO), Umet (United Phosphorous), Lumphate (Lupin), Agro-Phorate (Gujarat Agro), Helmet (Tropical Agro Chemicals), Warrant (Searle India), Hilphorate (Hindustan Insecticides), Grenades

PHOSALONE 35% EC & 4% Dust: Zolone (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), Ekator (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-Poulenc)

Fungicides

AUREOFUNGIN 46.15% SP: Aureofungin Sol (Hindustan Antibiotics)

CAPTAFOL 80%: Foltaf (Rallis)

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

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

EDIFENPHOS 50 EC: Hinosan (Bayer)

HEXCONAZOLE 5% EC: Contaf (Rallis)

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

PROPICONAZOLE: Radar (Rallis), Tilt (Novartis)

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

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

TRIDEMORPH 80% EC: Calixin (BASF)

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

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

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

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