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FOREWORD



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Agriculture production system of Odisha is fraught with the risk of vagaries of monsoon. Crops and cropping patterns of different agro climatic zones of Odisha are mostly driven by south west monsoon and water resources available in the region. The vagaries of South west monsoon and uncertainty in availability of irrigation water for crop production influences the productivity and profitability of a production system. The climate change due to global warming further makes the agriculture production more challenging. Judicious selection of crop and cropping system for a particular agroclimatic zone is required to sustain the crop production with minimum impact on environment.

The bulletin on “Crop planning and crop calendar for different agro climatic zones of Odisha” is an attempt to provide a comprehensive information on crops, cropping pattern with reference to sowing windows and harvesting period under different agro climatic zones of Odisha. This will help the stakeholders for optimum use of natural resources like land, water, sunshine etc. in crop production with higher productivity and profit.

I congratulate the authors for their efforts in bringing out this useful publication that would serve as a reference material for different stakeholders.

(D. Maiti)

PREFACE

Challenges in food production are becoming more complex. Factors affecting food production includes climate variability and climate change, particularly in eastern Indian state Odisha. Odisha is divided into ten distinct agro climatic zones based on soil types, topography, rainfall and cropping pattern. Economy of Odisha is driven by agriculture. Rice-based production system is dominant among the various cropping and farming systems adopted in Odisha in the various agro-climatic zones. Agriculture in Odisha mostly depends on south west monsoon. The agriculture in the state is severely affected due to increased frequency of droughts, floods and cyclone making the agricultural production more challenging for the farmers in the state. There is requirement for judicious selection of crop and cropping system for different agro climatic zones for sustaining the crop production with higher input use efficiency while conserving the natural resources. The knowledge of different cropping systems, sowing windows and harvesting time of suitable crops under, different agro climatic zones of Odisha will be immensely helpful for optimising the use of natural resources like land, water, sunshine, manpower with higher productivity and profit.

Realizing the need, ICAR-National Rice Research Institute has come forward and designed a crop calendar for different agroclimatic zones of Odisha in the form of a research bulletin. This crop calendar contains information on sowing, planting and harvesting periods of locally adapted crops in specific agro-climatic zones. This bulletin provides information to farmers and extension functionaries in taking appropriate decisions on crops and their sowing period in context of agro-ecological dimension. It also provides opportunity for emergency planning for rehabilitation of cropping systems after natural calamities.

The bulletin entitled “Crop planning and crop calendar for different agroclimatic zones of Odisha” is an attempt to provide a comprehensive information on crops sowing/planting calendar for different agroclimatic zones of Odisha. This bulletin would not only help farmers of Odisha but may prove to be immensely helpful in reorienting the policy framework for different agricultural schemes running in Odisha. Authors hope that farmers, researchers, planners and other stakeholders will find this publication useful.

Authors

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Crop planning and crop calendar for different agroclimatic zones

Odisha has a geographical area of 1.56 lakh sq. km. divided in to ten distinct agro climatic zones based on soil types, topography, rainfall and cropping pattern. Economy of Odisha is continuously driven by agriculture which provides employment and sustenance directly or indirectly to more than 60% of the state's total workforce (Anonymous, 2019). The total cultivated land of the state is 61.80 lakh ha out of which 29.14 lakh ha (47%) is high land 17.55 lakh ha (28%) medium land and 15.11 lakh ha (25%) low land. The soil of Odisha is enriched with 8 broad soil groups, out of these, red loam, red sandy soil and red and yellow soil covers about 81.1% of total land area (Anonymous, 2014).

The state experiences mostly sub-tropical climate which varies from hot and dry sub humid to hot and moist. Agriculture production in different regions of Odisha mostly depends on south west monsoon. The long-term average annual rainfall of the state is 1452 mm with a wide spatial variation of 1200 mm in southern coastal plain to about 1700 mm in northern plateau. About 78% of total annual rainfall occurs during *kharif* season *i.e* June to September and the balance 22% in the remaining period. The soil type, rain fall pattern and other ecological condition favours diversified agriculture in different seasons and ecologies. Water resources of the state is enriched by the presence of several major river basins. About 54% of agricultural land covered under irrigation facilities due to development of several minor, medium and major projects in different parts of Odisha. Favourable soil type, rainfall pattern, available water resources, socio economic condition and food habits of people of Odisha shaped the agriculture production system of the state.

The gross irrigated area in the state is 35.21 lakh ha (22.54 lakh ha during *kharif* and 12.67 lakh ha during *rabi*) which is 70.35% of the total irrigation potential created from different sources (Mohapatra, 2016). Crops and cropping patterns of different agro climatic zones of Odisha mostly depends on south west monsoon and irrigation potential available in the region. The intensity of rainfall and its distribution, prevailing temperature, types of soil and availability of irrigation water decides the safe crop growing period of a region. In Odisha, safe crop growing period varies from 70-90 days in rainfed unbunded uplands to 300 or more days in irrigated medium and shallow lowlands. Safe crop growing period influences the choice of crop and cropping sequence of a particular production system. The predominant crops and cropping systems varies with the agro climatic zone due to variation in rainfall pattern, soil type and available irrigation potentials.

Soil type, climatic condition and food habits of people ensures rice is the principle food crop of the state and grown in all ten agro climatic zones of Odisha in two distinct season i.e wet season (*kharif* rice) and dry season (*rabi* rice) under different ecologies. The rice area covers about 70 per cent of total cultivated area, 63 percent of total area under food grains and about 90 per cent area under cereals. At present nearly 4 m ha of area is covered annually under this crop (3.7 m ha during *kharif* & 0.3 m ha during *rabi*). The *kharif* paddy area includes 1.27 m ha of high land, 1.43 m ha of medium land and 1.47 m ha of low land. Besides rice, maize, ragi, and millets are other cereals grown under different agro-climatic zones of Odisha. Pulses are the second most important food grain crop next to cereals. Green-gram, black-gram, red-gram, horse-gram, chick pea, lentil, field-pea, lathyrus and cowpea are major pulses grown in Odisha. Groundnut, sesame, sunflower, safflower, nizer, mustard and toria, linseed, castor are major oil seeds grown in different season and agro-climatic zones of Odisha. In addition to food grain crops, farmers of Odisha grow several cash crops like sugarcane, cotton, chilli, potato, sweet potato, yams, onion etc. Prevailing long safe growing period in different agro climatic zones and ecologies favours multiple cropping with average cropping intensity of 167%. Among the various cropping and farming systems adopted in Odisha, rice-based production system is dominant in majority of the cultivated land across the various agro-climatic zone. Rice-rice, rice-green gram, rice-black gram, rice-ground nut are major cropping systems dominates in all 10 agro-climatic zones of Odisha.

The vagaries of South west monsoon results droughts in some parts of the state and floods in some others at a frequent interval causing severe reduction in crop production. Non availability assured irrigation facilities further adds uncertainty nature of rice production system in Odisha. The climate change due to global warming further makes the agriculture production more challenging. Judicious selection of crop and cropping system for a particular agro climatic zone is required to sustain the crop production and higher input use efficiency by conserving the natural resources with minimum impact on environment in a particular agroclimatic zone. The sound knowledge of sowing windows and harvesting time of different crops under different cropping systems, ecologies of different agro climatic zones of Odisha will be helpful for optimum use of natural resources like land, water, sunshine, manpower etc. in agriculture with higher productivity and profit. The crop and cropping calendar of different cropping systems under different agro climatic zones are described below.

(i) North western plateau agro-climatic zone

Sundargarh and Deogarh districts come under North western plateau agro-climatic zone. The zone experiences hot and moist sub-humid climate with mean annual rainfall of 1648mm, having mean maximum summer temperature of 38.0 °C and mean minimum winter temperature of 15.0 °C. Red, brown forest, red and yellow, mixed red and black soil group are predominant in the region. Brahmani and Baitarani river basins influence the agriculture of the agro-climatic zone. Irrigation ratio of the region is 30.4% (Pattanayak and Mallick, 2018). The land type varies from unbunded upland to shallow lowland.

Rice being the major food crop of the region grown in three distinct season i.e *autum (biali dhan)*, *kharif (sarad dhan)* and *rabi (dalua dhan)* under different ecologies. *Autum* rice is mostly confined to upland and short duration varieties having 80 to 95 days' duration (Kalinga III, Khandagiri, Parijat and Sidhanta) etc. are recommended for rainfed upland whereas CR-Dhan 100 and CR Dhan 101 can safely grow in irrigated upland. Medium duration varieties like Bina dhan 11, Naveen, MTU 1001, CR Dhan 310, CR Dhan 303, Konark and hybrids like Ajaya and Rajalaxmi are suitable for both rainfed and irrigated medium land. Long duration varieties Mahanadi, Indravati, Dharitri and Sarala are cultivated in lowlands. Satabdi, Binadhan 11, MTU 1001 are suitable for rabi season. Besides rice, maize, jowar, ragi, greengram, redgram, blackgram, groundnut, sesame, sweet potato and chillies grown in substantial areas during *kharif* season.

Selection of suitable medium duration rice varieties and adoption of suitable conservation practices and irrigation facilities promotes multiple cropping in rainfed medium and shallow lowland. Rice-groundnut, rice-greengram, rice-blackgram, rice-chickpea and rice-fieldpea, rice-linseed, rice-horse gram, rice-lentil and rice-rice are major cropping systems practiced in the region.

Drought is the major abiotic stress which affects the crop production in this agro-climatic zone. Rabi rice suffers from cold stress in early season and terminal heat stress. Selection of suitable early/ medium duration rice varieties and appropriate time of planting and crop establishment method ensures higher cropping intensity. Proper selection of crop and ideal sowing time are key factor for better utilization of precise natural resources for enhancing crop production without degrading the ecology. Different crop establishment methods also influence the sowing window which ultimately decides the cropping pattern. Based on safe crop growing period, ecology and suitability of *rabi* crops, the crop calendar of different cropping systems of the agro-climatic zone are described in Fig. 1, 2. Based on the establishment methods, sowing/ planting windows and ecology, the crop calendar of rice is presented in Table 1.

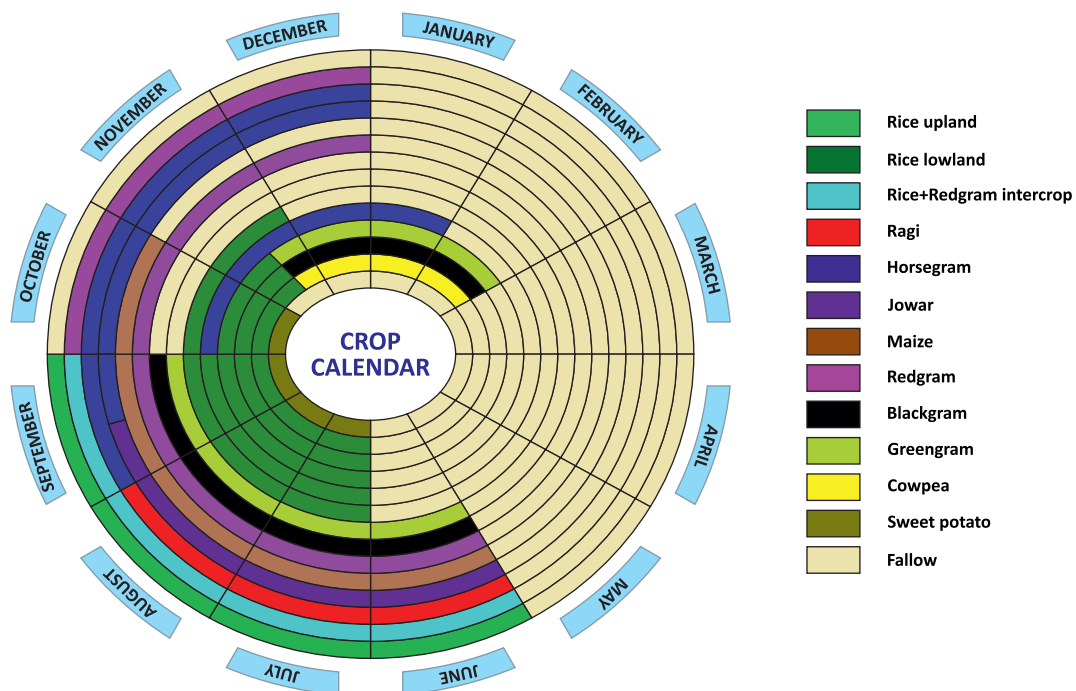


Fig 1. Crop calendar of North western plateau zone for rainfed situation

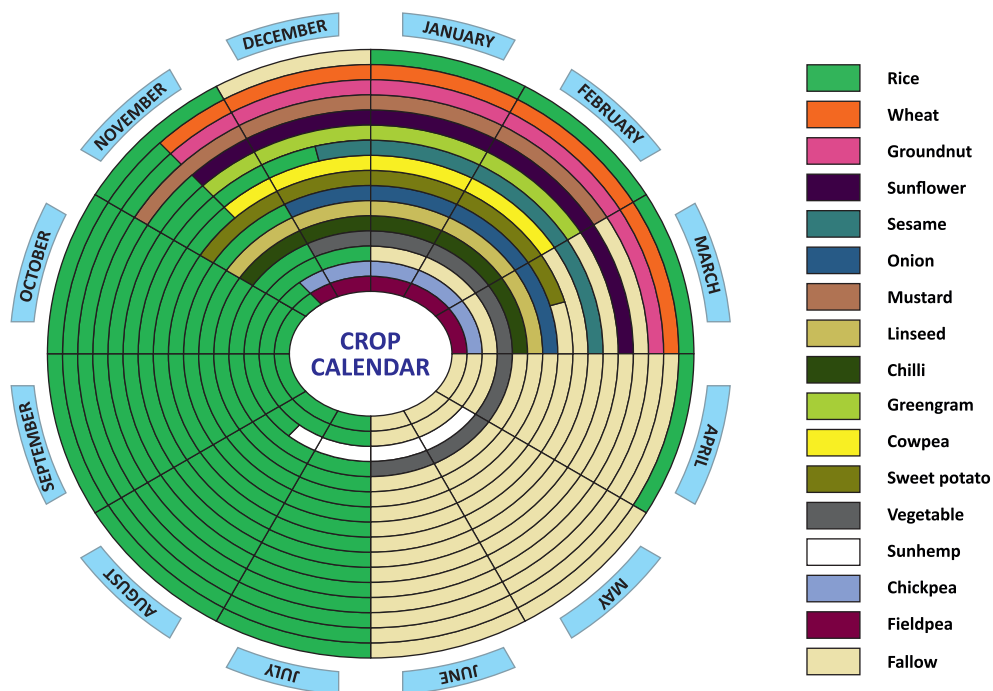


Fig 2. Crop calendar of North western plateau zone for irrigated situation

Table 1: Rice crop calendar for North western plateau zone

Rice ecology/ Wet season	Crop Estab- lishment	January	February	March	April	May	June	July	August	September	October	November	December
Rainfed Upland	DSR												
Irrigated upland	DSR												
Rainfed medium land	DSR												
Rainfed medium land	TPR												
Irrigated medium land	DSR												
Irrigated medium land	TPR												
Rainfed shallow lowland	DSR												
Rainfed shallow lowland	TPR												
Irrigated shallow lowland	DSR												
Irrigated shallow lowland	TPR												
Rainfed semi deep	DSR												
Rainfed semi deep	TPR												
Irrigated semi deep	DSR												
Irrigated semi deep	TPR												
Dry season													
Medium/shallow lowland	TPR												
Medium/shallow lowland	Wet DSR												
Medium/shallow lowland	SRI												

DSR - Direct Seeded Rice; TPR - Transplanted Rice; SRI - System of Rice Intensification
 Sowing window in Nursery (Yellow) Sowing window in main field (Green) Transplanting window (Orange) Crop growth period (Dark Green) Harvesting period (Light Green)

(ii) North central plateau agro-climatic zone:

Mayurbhanj and Keonjhar districts of Odisha comes under North central plateau agro-climatic zone. The zone experiences hot and moist climate with mean annual rainfall of 1535mm, having mean maximum summer temperature of 36.6 °C and mean minimum winter temperature of 11.1 °C. Broad soil groups of the region include lateritic, red and yellow and mixed red and black. Besides rain fall, Subernarekha, Burhabalanga, Baitarani and Brahmani river basins are source of water resources of the region. The Irrigation ratio of the region is 33.9%. Land types varies from upland to semi deep water lowlands.

Rice is grown in *autumn (bialidhan)*, *kharif (saraddhan)* and *rabi (daluadhan)* season in this agro-climatic zone under different ecologies. Kalinga III, Khandagiri, Parijat, Sidhanta and Vandana are recommended for dry direct sowing in rainfed upland as autumn rice, whereas CR-Dhan 100 and CR Dhan 101 can safely be grown in irrigated upland. Medium duration varieties like Bina dhan 11, Naveen, MTU 1001, MTU 1010, CR Dhan 310, CR Dhan 303, DR dhan 45 and Konark are suitable for rainfed medium land whereas CR Dhan 307, Improved Tapaswini, Ajaya and Rajlaxmi are ideal for irrigated ecologies. Long duration varieties CR Dhan 401, Savitri, Sarala, Gayatri, CR Dhan 908, Kalachampa and CR Dhan 910 are recommended for lowland rice ecologies. Satabdi, Binadhan 11, MTU 1001 and Lalat are promising during summer season. Besides rice, maize and wheat are other important cereal crops grown in *kharif* and *rabi* season respectively. Selection of suitable early/ medium duration rice varieties and appropriate time of planting will ensure higher cropping intensity with the inclusion of short duration pulses, oil seeds and vegetables in rice fallow. Among the cropping systems, rice-based production system is dominant in the region. Rice-horsegram, rice-green gram, rice- blackgram, rice-rice, rice-chick pea, rice-field pea, rice-lentil, rice-groundnut, rice-mustard and rice-linseed are major cropping systems followed in the region.

Drought and floods are major abiotic stresses influences the crop production in the region. Rice in *rabi* season suffers from cold stress at early growth stage and terminal heat stress at maturity. Based on available growing period and ecology, the crop calendar of different crop and cropping systems are described in Fig 3, 4. Based on the establishment methods, sowing/ planting windows and ecology, the crop calander of rice is presented in Table 2.

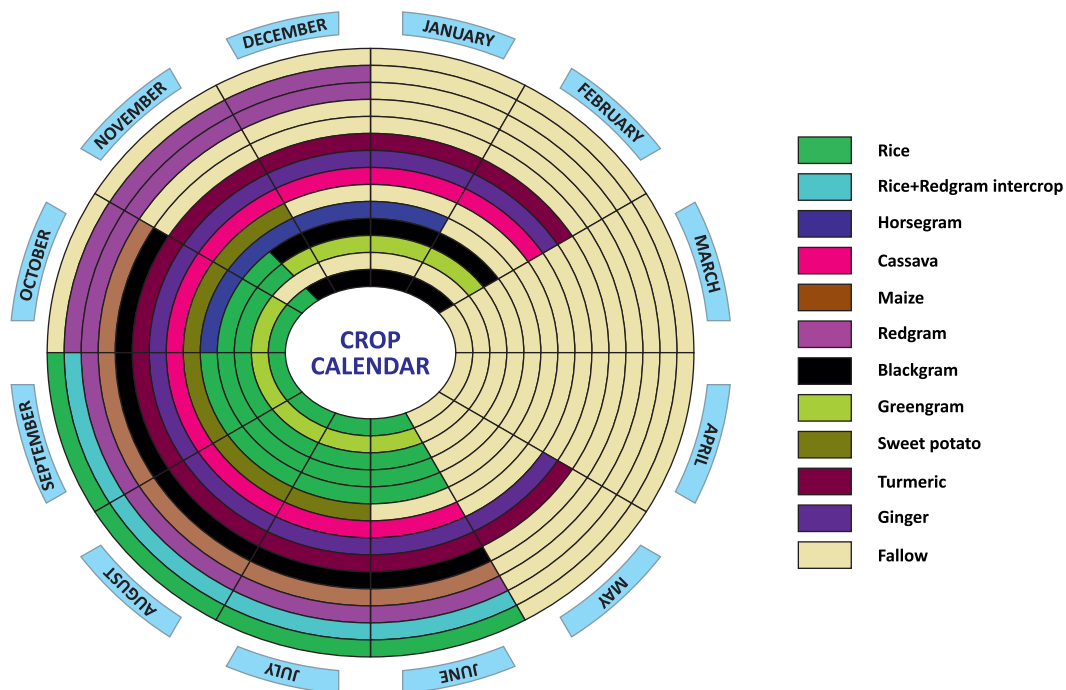


Fig 3. Crop calendar of North central plateau zone for rainfed situation

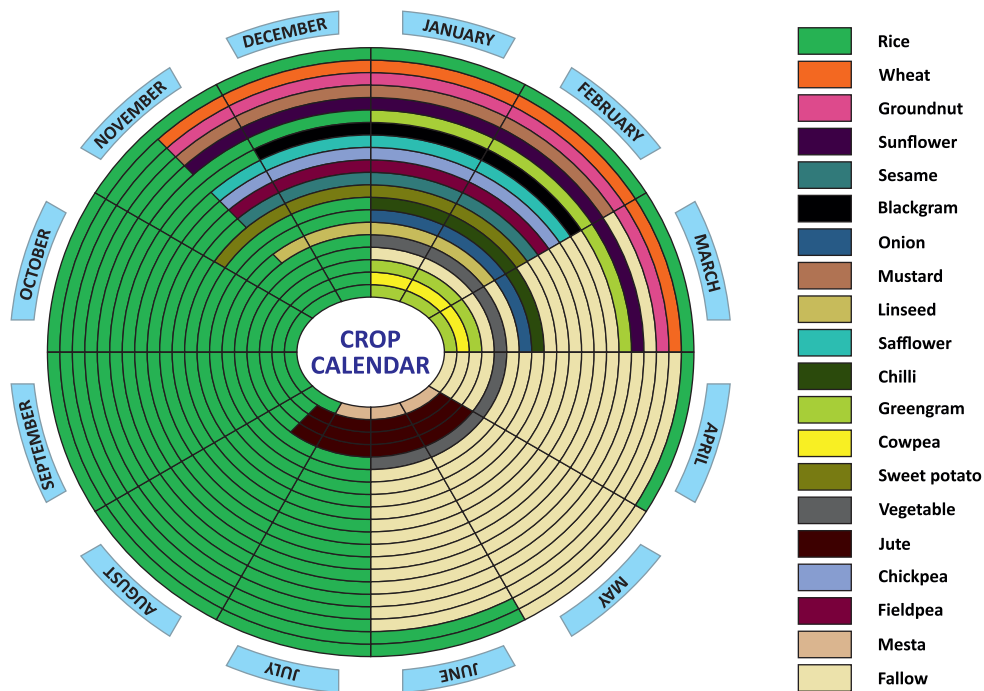


Fig 4. Crop calendar of North central plateau zone for irrigated situation

Table 2: Rice crop calendar for North central plateau zone

Rice ecology/ Wet season	Crop Establishment	January	February	March	April	May	June	July	August	September	October	November	December
Rainfed Upland	DSR												
Irrigated upland	DSR												
Rainfed medium land	DSR												
Rainfed medium land	TPR												
Irrigated medium land	DSR												
Irrigated medium land	TPR												
Rainfed shallow lowland	DSR												
Rainfed shallow lowland	TPR												
Irrigated shallow lowland	DSR												
Irrigated shallow lowland	TPR												
Rainfed semi deep	DSR												
Rainfed semi deep	TPR												
Irrigated semi deep	DSR												
Irrigated semi deep	TPR												
Dry season													
Medium/shallow lowland	TPR												
Medium/shallow lowland	Wet DSR												
Medium/shallow lowland	SRI												

DSR - Direct Seeded Rice; TPR - Transplanted Rice; SRI - System of Rice Intensification
 Sowing window in Nursery (Yellow) Sowing window in main field (Orange) Transplanting window (Brown) Crop growth period (Green) Harvesting period (Light Green)

(iii) North eastern costal plain agro-climatic zone

Balasore, Bhadrak and Jajpur come under North central plateau agro-climatic zone. The zone experiences hot and moist sub humid climate with mean annual rainfall of 1568mm, having mean maximum summer temperature of 36.0°C and mean minimum winter temperature of 14.8°C. Broad soil groups of the region are red, lateritic, deltaic alluvial, coastal alluvial, saline red, yellow and mixed red and black. Subernarekha, Burhabalanga and Baitarani river basin covers majority of agricultural lands of the region. Irrigation situation of the region is comparatively better than other regions of Odisha having irrigation ratio 60.7%. Land types varies from upland to deep water rice ecologies.

Kharif (*saraddhan*) and *rabi* (*daluadhan*) rice is mostly cultivated in this zone under various ecologies. *Autum* rice is mostly confined to uplands of Jajpur district. Short duration varieties like Khandagiri, Parijat, Sidhanta and Vandana etc. are recommended for dry direct sowing in rainfed upland whereas CR-Dhan 100, CR Dhan 101 and CR Dhan 203 can safely be grown in irrigated upland. Medium duration varieties like Bina dhan 11, Naveen, CR Dhan 310, CR Dhan 303, DR dhan 45 and Konark are suitable for rainfed medium land whereas CR Dhan 307, Improved Tapaswini, Swarna, Pratikshya, Ajaya and Rajlaxmi are ideal for irrigated ecologies. Long duration varieties Pooja, CR Dhan 401, Savitri, Sarala, Gayatri, CR Dhan 908, Kalachampa and CR Dhan 910 are recommended for lowland rice ecologies. Swarna sub-1, CR 1009 sub-1, Ranjit sub-1 are ideal varieties for flood prone areas. Varshadhan, CR Dhan 505 and CR Dhan 508 are suitable for semi deep water rice ecologies. Satabdi, Binadhan 11, MTU 1001 and Lalat are promising *rabi* rice varieties. Besides rice, maize and wheat are other important cereal crops grown in *kharif* and *rabi* season respectively. Among the cropping systems, rice-based production system is dominant in the region. Rice-rice, rice-green gram, rice-black gram, rice-groundnut, rice-mustard, rice-sesame, rice-sunflower, rice-onion, rice-chilies are major cropping systems followed in the region.

Selection of suitable early/ medium duration rice varieties and appropriate time of planting will ensure higher cropping intensity with the inclusion of short duration pulses, oil seeds and vegetables in rice fallow. Drought, cyclone and floods are major abiotic stresses influences the cropping pattern, crop planning and production in the region. Based on safe crop growing period, ecologies and suitable *rabi* crops the crop calendar of different cropping systems are described in Fig 5, 6. Based on the establishment methods, sowing/ planting windows and ecology, the crop calendar of rice is presented in Table 3.

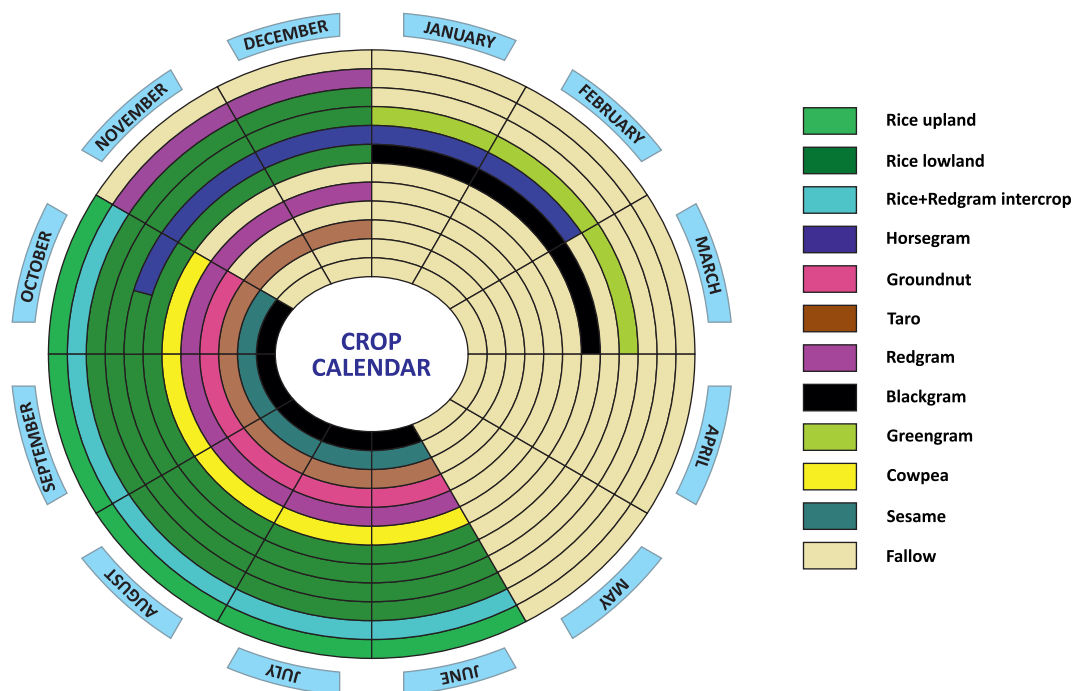


Fig 5. Crop calendar of North eastern coastal plain zone for rainfed situation

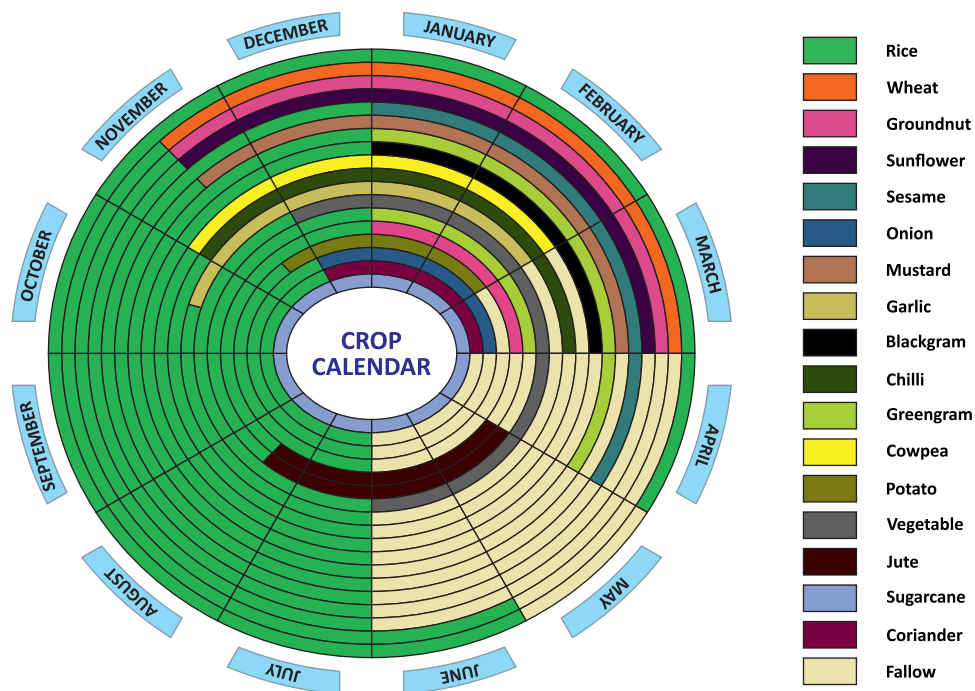


Fig 6. Crop calendar of North eastern coastal plain zone for irrigated situation

Table 3: Rice crop calendar for North eastern coastal plain zone

Rice ecology/ Wet season	Crop Estab- lishment	January	February	March	April	May	June	July	August	September	October	November	December
Rainfed Upland	DSR												
Irrigated upland	DSR												
Rainfed medium land	DSR												
Rainfed medium land	TPR												
Irrigated medium land	DSR												
Irrigated medium land	TPR												
Rainfed shallow lowland	DSR												
Rainfed shallow lowland	TPR												
Irrigated shallow lowland	DSR												
Irrigated shallow lowland	TPR												
Rainfed semi deep	DSR												
Rainfed semi deep	TPR												
Irrigated semi deep	DSR												
Irrigated semi deep	TPR												
Rainfed deep land	DSR												
Dry season													
Medium/shallow lowland	TPR												
Medium/shallow lowland	Wet DSR												
Medium/shallow lowland	SRI												

DSR - Direct Seeded Rice; TPR - Transplanted Rice; SRI - System of Rice Intensification
 Sowing window in Nursery  Sowing window in main field  Crop growth period  Harvesting period  Transplanting window 

(iv) East and south eastern coastal plain agro-climatic zone

Kendrapara, Khurda, Jagatsingpur, Cuttack, Puri and Nayagada districts of Odisha comes under East and South eastern coastal plain agro-climatic zone. The zone experiences hot and humid climate with mean annual rainfall of 1449mm, having mean maximum summer temperature of 39.0 °C and mean minimum winter temperature of 11.5 °C. Baitarani, Brahmani and Mahanadi river basin influences the agriculture and civilization of the region. Broad soil groups of the region are saline, lateritic, alluvial, red and mixed red. Irrigation ratio of the region is 53.4%.

Rice being the major cereal crop of the region grown in three distinct seasons under different ecologies. Land type, water resources and season decides the suitable rice varieties and crop establishment method to be adopted in a particular agro-climatic zone. Short duration varieties like Khandagiri, Parijat, Anjali are recommended for dry direct sowing in rainfed upland whereas CR-Dhan 100, CR Dhan 101, Sahabhagidhan and CR Dhan 203 can safely grow in irrigated upland. Medium duration varieties like Bina dhan 11, Naveen, CR Dhan 310 etc are suitable for rainfed medium land whereas CR Dhan 307, Swarna, Pratikshya, Geetanjali, Ajaya, Rajlaxmi etc. are ideal for irrigated ecologies. Long duration varieties like Pooja, Savitri, Sarala *etc.* are recommended for lowland rice ecologies. Swarna sub1, CR 1009 sub 1, Ranjit sub1 are ideal varieties for flood prone areas. Varshadhan, CR Dhan 505 and CR Dhan 508 are suitable for semi deep water rice ecologies. Summer rice is gaining popularity in irrigated regions and short duration photo insensitive varieties are recommended for cultivation. Rice-rice, rice-greengram, rice-blackgram, rice-groundnut, rice-mustard, rice-sunflower, rice-onion are major cropping systems followed in the region.

Climatic condition, soil type, water resources, availability of energy for agriculture and demand of inhabitants influences the crop and cropping pattern of the region. Major abiotic stresses like drought, cyclone and floods which influences the sowing time, methods of crop establishment and cropping sequence under a particular production system. Selection of suitable early/ medium duration rice varieties and appropriate time of planting and crop establishment method ensures higher cropping intensity. Proper selection of crop and ideal sowing time are key factor for better utilization of precise natural resources for enhancing crop production without degrading the ecology. Different crop establishment methods also influence the sowing window which ultimately decides the cropping pattern. Based on the ecologies, safe crop growing period and suitable *rabi* crops, the crop calendar of different cropping systems of East and south eastern coastal plain agro-climatic zone are described in Fig 7, 8. Based on the establishment methods, sowing/ planting windows and ecology, the crop calendar of rice is presented in Table 4.

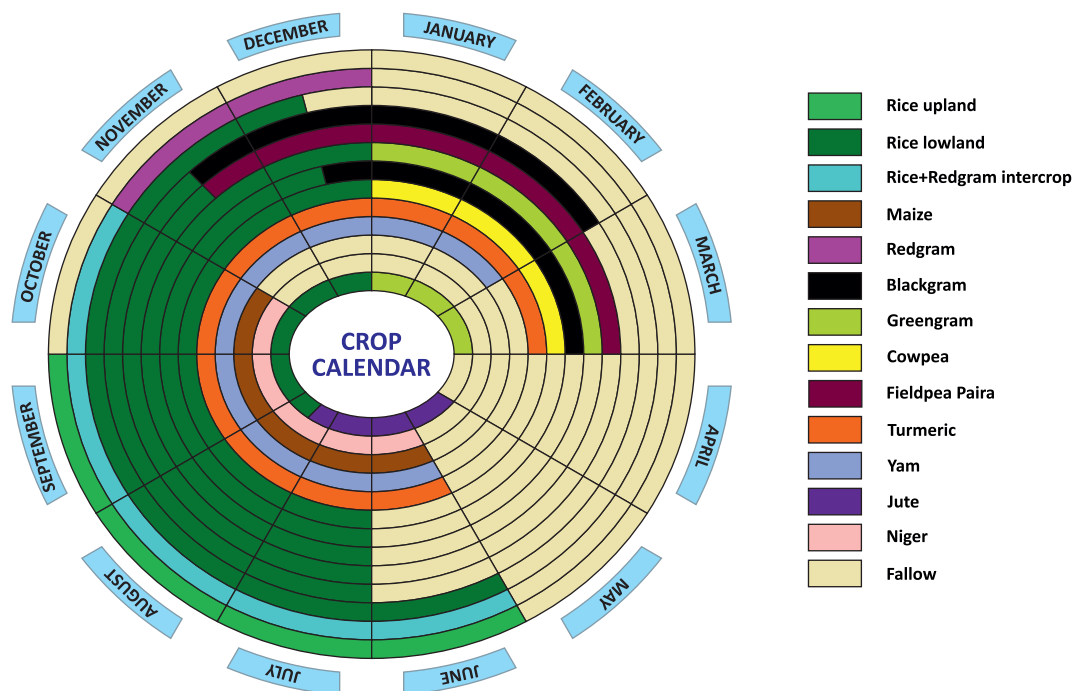


Fig 7. Crop calendar of East and South-Eastern Coastal zone for Rainfed situation

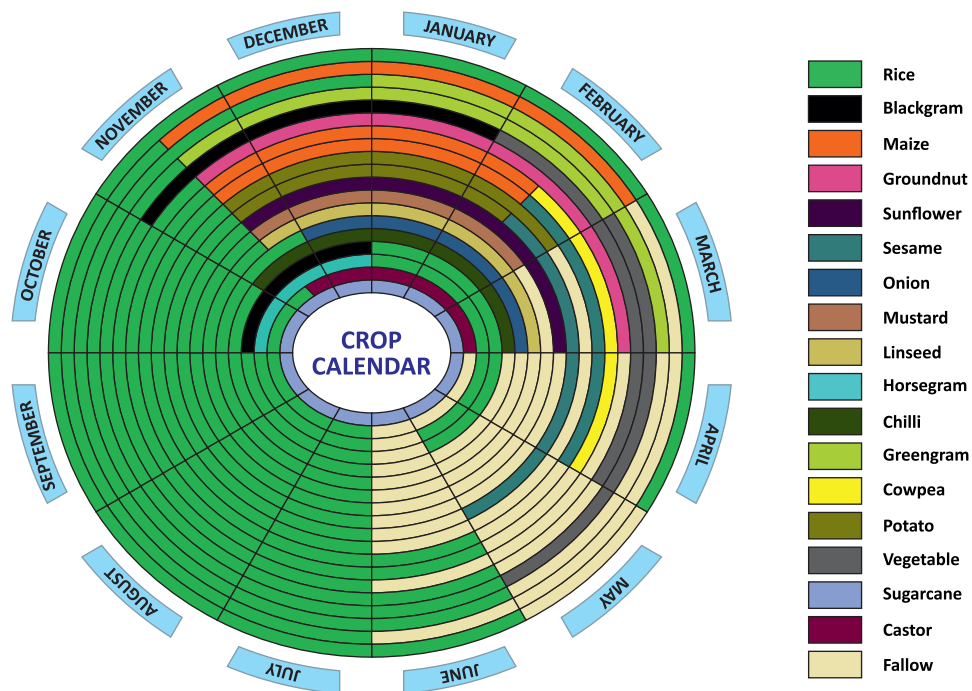


Fig 8. Crop calendar of East and South-Eastern Coastal Plain zone for irrigated situation

Table 4: Rice crop calendar for East and South eastern coastal plain

Rice ecology/ Wet season	Crop Estab- lishment	January	February	March	April	May	June	July	August	September	October	November	December
Rainfed Upland	DSR												
Irrigated upland	DSR												
Rainfed medium land	DSR												
Rainfed medium land	TPR												
Irrigated medium land	DSR												
Irrigated medium land	TPR												
Rainfed shallow lowland	DSR												
Rainfed shallow lowland	TPR												
Irrigated shallow lowland	DSR												
Irrigated shallow lowland	TPR												
Rainfed semi deep	DSR												
Rainfed semi deep	TPR												
Irrigated semi deep	DSR												
Irrigated semi deep	TPR												
Rainfed deep land	DSR												
Dry season		January	February	March	April	May	June	July	August	September	October	November	December
Medium/shallow lowland	TPR												
Medium/shallow lowland	Wet DSR												
Medium/shallow lowland	SRI												

DSR - Direct Seeded Rice; TPR - Transplanted Rice; SRI - System of Rice Intensification

□ Sowing window in Nursery

□ Sowing window in main field

□ Transplanting window

□ Crop growth period

□ Harvesting period

(v) North eastern ghat agro-climatic zone

Ganjam, Gajapati, Rayagada and Kandhamal districts of Odisha comes under North eastern ghat agro-climatic zone. The zone experiences hot and moist sub-humid climate with mean annual rainfall of 1597mm, mean maximum summer temperature of 37.0 °C and mean minimum winter temperature of 10.4 °C. Rushikulya, Bahuda, Vansadhara, Nagabali and Indravati river basin enriches the agricultural lands of the region. Brown forest, lateritic, lateritic alluvial, red, mixed red and black soils are major soil groups of the region with irrigation ratio of 27.4%.

Rice being the major cereal crop of the region grown in three distinct season under different ecologies. Land type and water resources influence the rice season and culture. Upland rice is dominant in Rayagada and Kandhamal districts and short duration varieties like Khandagiri, Parijat, Anjali, Sahabthagidhan are popular among the farming community in drought prone areas. Early medium and medium duration varieties are recommended for medium land. CR Dhan 202, CR Dhan 205, CR Dhan 206, CR Dhan 209 etc. are suitable aerobic rice for irrigated medium land. Ajay, Rajlaxmi, Maudamani, Swarna, Pratikshya, Lalat *etc* are suitable under shallow low land. In assured irrigated area cultivation of summer rice is gaining popularity. Besides rice, crops such as ragi, maize, small millets are grown in substantial area under rainfed condition during wet season. Irrigated ragi in *rabi* season is another popular food crop of the agro-climatic zone. Rice-maize, rice-green gram, rice-black gram, rice-mustard, rice-groundnut, rice-horse gram are major cropping systems seen in the agro-climatic zone. With the availability of photo insensitive short duration varieties, summer rice is grown in assured irrigated areas.

Drought, cyclone, floods are major abiotic stresses affecting the agriculture in the region. Among these, frequent occurrence of drought of various intensities affects crop production in all the 4 districts of the region during wet season. Proper selection of crop and ideal sowing time are key factor for efficient utilization of natural resources. Availability of water resources, late onset of south west monsoon influences the sowing window of a particular crop. Based on ecologies, length of growing period, types of *rabi* crop suitable for the area the crop calendars of the North eastern ghat agro-climatic zone are presented in Fig. 9, 10. Based on the establishment methods, sowing/ planting windows and ecology, the crop calendar of rice is presented in Table 5.

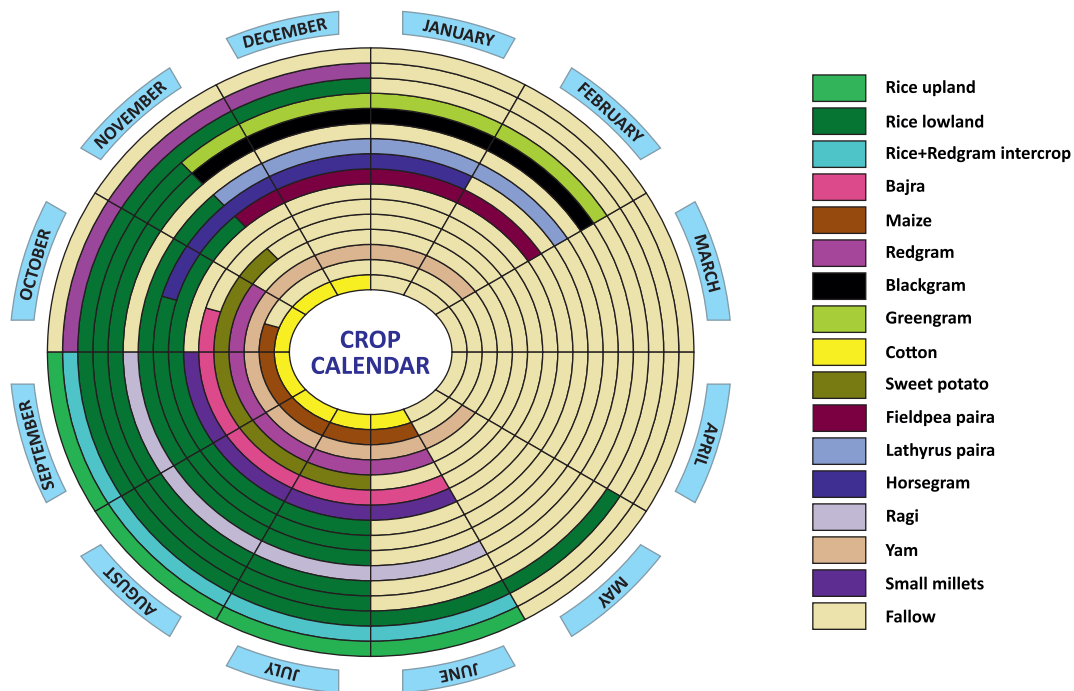


Fig 9. Crop calendar of North eastern ghat zone for rainfed situation

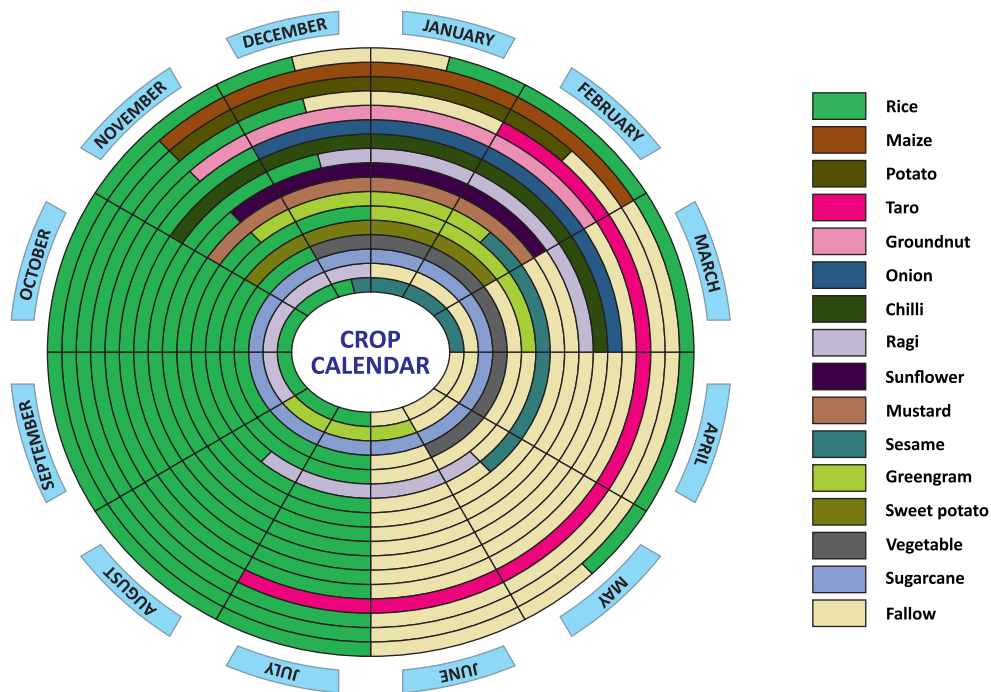


Fig 10. Crop calendar of North eastern ghat zone for irrigated situation

Table 5: Rice crop calendar for North eastern ghat zone

Rice ecology/ Wet season	Crop Estab- lishment	January	February	March	April	May	June	July	August	September	October	November	December
Rainfed Upland	DSR												
Irrigated upland	DSR												
Rainfed medium land	DSR												
Rainfed medium land	TPR												
Irrigated medium land	DSR												
Irrigated medium land	TPR												
Rainfed shallow lowland	DSR												
Rainfed shallow lowland	TPR												
Irrigated shallow lowland	DSR												
Irrigated shallow lowland	TPR												
Rainfed semi deep	DSR												
Rainfed semi deep	TPR												
Irrigated semi deep	DSR												
Irrigated semi deep	TPR												
Dry season													
Medium/shallow lowland	TPR												
Medium/shallow lowland	Wet DSR												
Medium/shallow lowland	SRI												

DSR - Direct Seeded Rice; TPR - Transplanted Rice; SRI - System of Rice Intensification
 Sowing window in Nursery (Yellow) Sowing window in main field (Orange) Transplanting window (Brown) Crop growth period (Green) Harvesting period (Light Green)

(vi) Eastern ghat high land agro-climatic zone

Nabarangapur and parts of Koraput districts comes under Eastern ghat high land agro-climatic zone. The zone experiences warm and humid climate with mean annual rainfall of 1522mm, having mean maximum summer temperature of 34.1°C and mean minimum winter temperature of 7.5°C. Broad soil groups of the region are red and mixed red and black, mixed red and yellow. Irrigation ratio of the region is 32.0%. The land types vary from hill regions with variable slopes to plateau mostly comes under upland and medium land. Indravati and Kolab river basin enriches the flora and fauna of the agro-climatic zone.

Rice is the principle food crop grown in two distinct seasons (*autumn* and *kharif* rice) during wet period. Rabi rice is gaining popularity in assured irrigated areas in some pockets. Khandagiri, Parijat, Anjali, Ananda, Sahabthagidhan are popular in drought prone areas. Early medium and medium duration varieties are recommended for medium land. CR Dhan 202, CR Dhan 205, CR Dhan 206 etc. are suitable aerobic rice varieties for irrigated medium land. Ajaya, Rajlaxmi, Maudamani, Swarna, Pratikshya, Lalat etc are suitable under shallow low land. Indravati and Utakalprava are suitable for lowlands. Besides rice, crops such as ragi, maize, small millets, blackgram and redgram are grown in substantial area under rainfed condition during wet season. Rice-maize, rice-greengram, rice-chickpea, rice-horse gram, rice-castor, rice-linseed and rice-mustard are major cropping systems followed in the agro-climatic zone. Beside rice-based cropping systems, turmeric, ginger, sweet potato and cassava are major root and tuber crops favorable for the region.

The rainfall pattern, soil type, topography, prevailing climate, availability of work forces, water resources determines the choice of crop, crop establishment methods, cropping pattern of the agro-climatic zone. Upper Kolab and Indravati irrigation project created scope for growing multiple crops in the command area. Drought, floods and acidity are major abiotic stresses influencing the crop production in the region. Based on ecologies, safe crop growing period and local demands the crop and crop calendar for different cropping systems of the Eastern ghat high land agro-climatic zone are presented in Fig 11, 12. Based on the establishment methods, sowing/ planting windows and ecology, the crop calendar of rice is presented in Table 6.

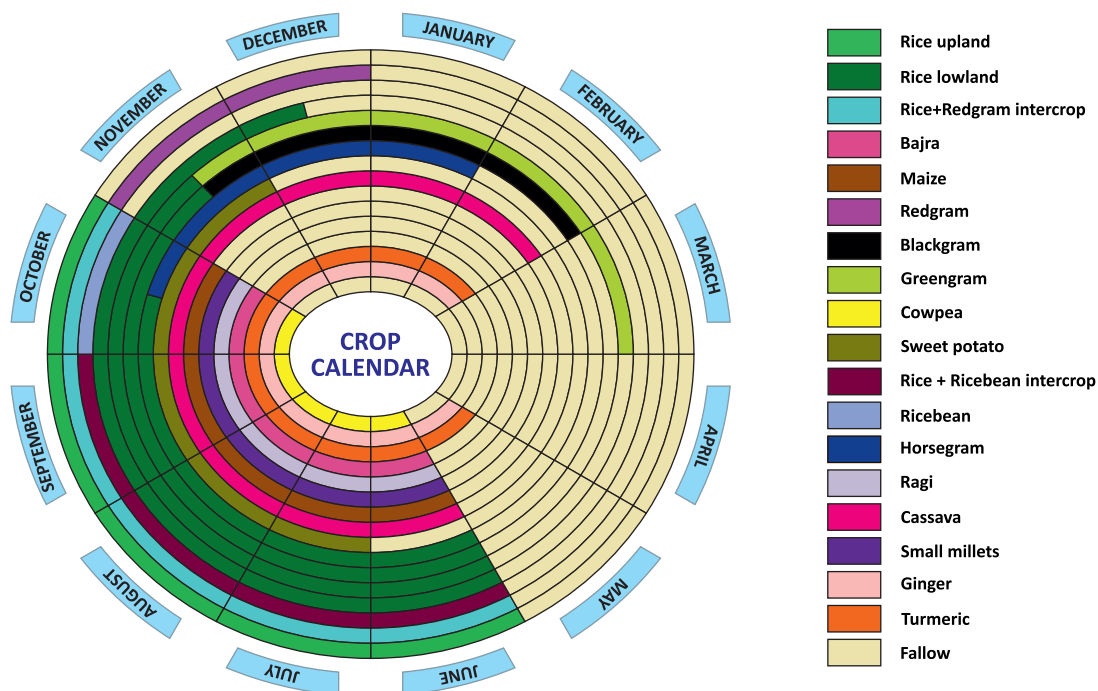


Fig 11. Crop calendar of Eastern ghat highland zone for rainfed situation

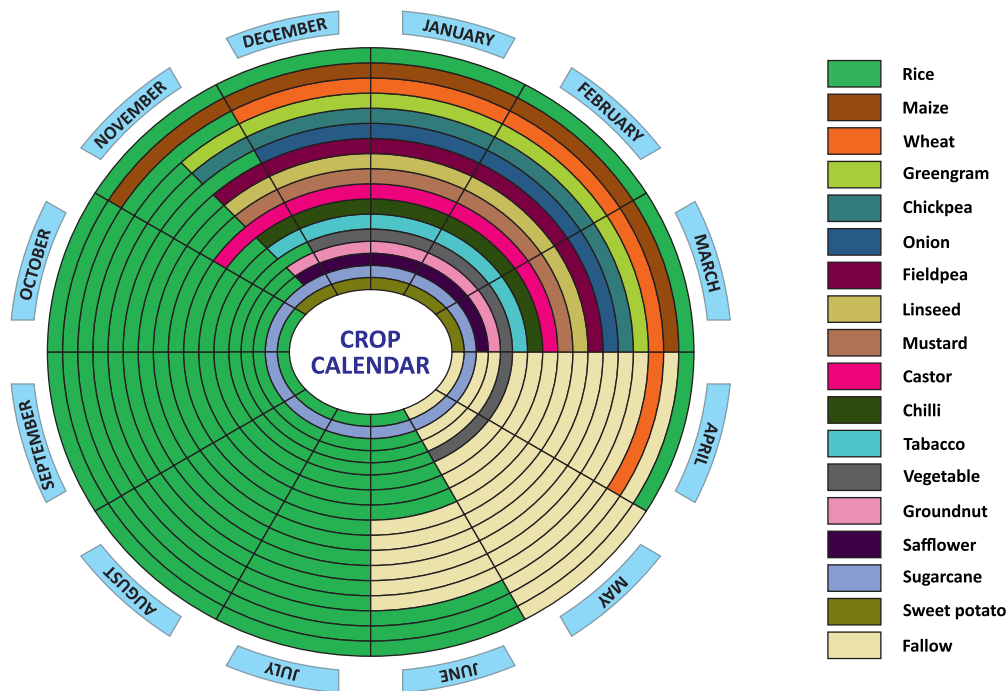


Fig 12. Crop calendar of Eastern ghat highland zone for irrigated situation

Table 6: Rice crop calendar for Eastern ghat highland zone

Rice ecology/ Wet season	Crop Establishment	January	February	March	April	May	June	July	August	September	October	November	December
Rainfed Upland	DSR												
Irrigated upland	DSR												
Rainfed medium land	DSR												
Rainfed medium land	TPR												
Irrigated medium land	DSR												
Irrigated medium land	TPR												
Rainfed shallow lowland	DSR												
Rainfed shallow lowland	TPR												
Irrigated shallow lowland	DSR												
Irrigated shallow lowland	TPR												
Rainfed semi deep	DSR												
Rainfed semi deep	TPR												
Irrigated semi deep	DSR												
Irrigated semi deep	TPR												
Dry season													
Medium/shallow lowland	TPR												
Medium/shallow lowland	Wet DSR												
Medium/shallow lowland	SRI												

DSR - Direct Seeded Rice; TPR - Transplanted Rice; SRI - System of Rice Intensification

Sowing window in Nursery

Sowing window in main field

Transplanting window

Crop growth period

Harvesting period

(vii) South eastern ghat agro-climatic zone

Malkangiri and parts of Koraput districts come under South eastern ghat agro-climatic zone. The zone experiences warm and humid climate with mean annual rainfall of 1522 mm, having mean maximum summer temperature of 34.1 °C and mean minimum winter temperature of 13.2 °C. Nagabali, Indravati and Kolab river basins influence the agriculture and civilization of the zone. Red, lateritic and black soils are major soil groups spread in the different parts of the region. Irrigation ratio of the region is 39.3%. The land types vary from hill regions with variable slopes to plateau mostly comes under upland and low land.

Rice is the principle food crop grown in two distinct seasons (autumn and winter rice) during wet period. Summer rice is gaining popularity in assured irrigated areas in some pockets of Koraput district. Kalinga III, Khandagiri, Parijat, Ananda, Sahabhagidhan are popular rice varieties in drought prone areas. Early medium and medium duration varieties like Binadhan 11, DR dhan 45, Naveen, CR Dhan 310 are recommended for medium land. CR Dhan 202, CR Dhan 205, CR Dhan 206 etc. are suitable aerobic rice for irrigated medium land. Ajaya, Rajlaxmi, Maudamani, Swarna, Pratikshya, Lalat etc are suitable under shallow low land. Indravati, Gayatri, Utakalprava are suitable for lowlands. Besides rice, ragi, maize, small millets, blackgram, redgram and niger are grown in substantial area under rainfed condition during wet season. Rice-maize, rice-green gram, rice-chickpea, rice-field pea, rice-cowpea, rice-horsegram, rice-groundnut, rice-sesamum and rice-mustard are major cropping systems followed in the agro-climatic zone. Beside rice-based cropping systems, turmeric, ginger, sweet potato and cassava are major root and tuber crops of the region.

The selection of crop, sowing time, cropping pattern and crop establishment method in the agro-climatic zone mostly influenced by soil type, topography, rainfall pattern, availability of work forces and water resources. Upper Kolab, Indravati and Nagabali irrigation project facilitated multiple cropping in the command area. Drought, floods, soil acidity in wet season and cold stress in *rabi* season influences the crop production in the region. Based on ecology, safe crop growing period and local demands, the crop and crop calendar for different cropping systems of the South eastern ghat agro-climatic zone are presented in Fig 13, 14. Based on the establishment methods, sowing/ planting windows and ecology, the crop calendar of rice is presented in Table 7.

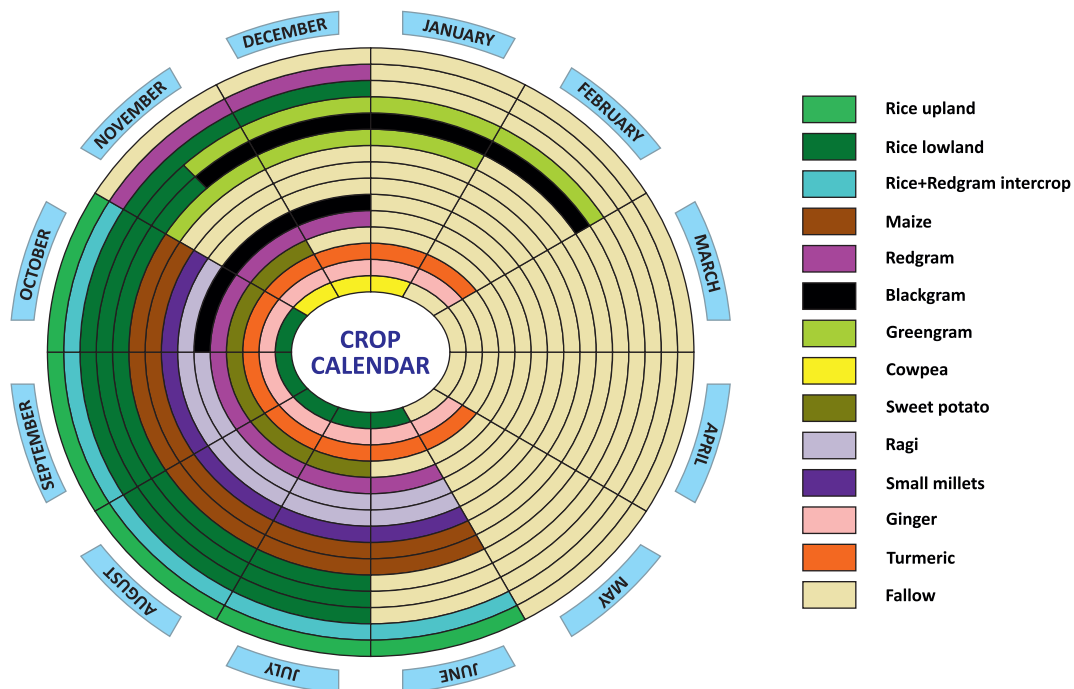


Fig 13. Crop calendar of South eastern ghat zone for rainfed situation

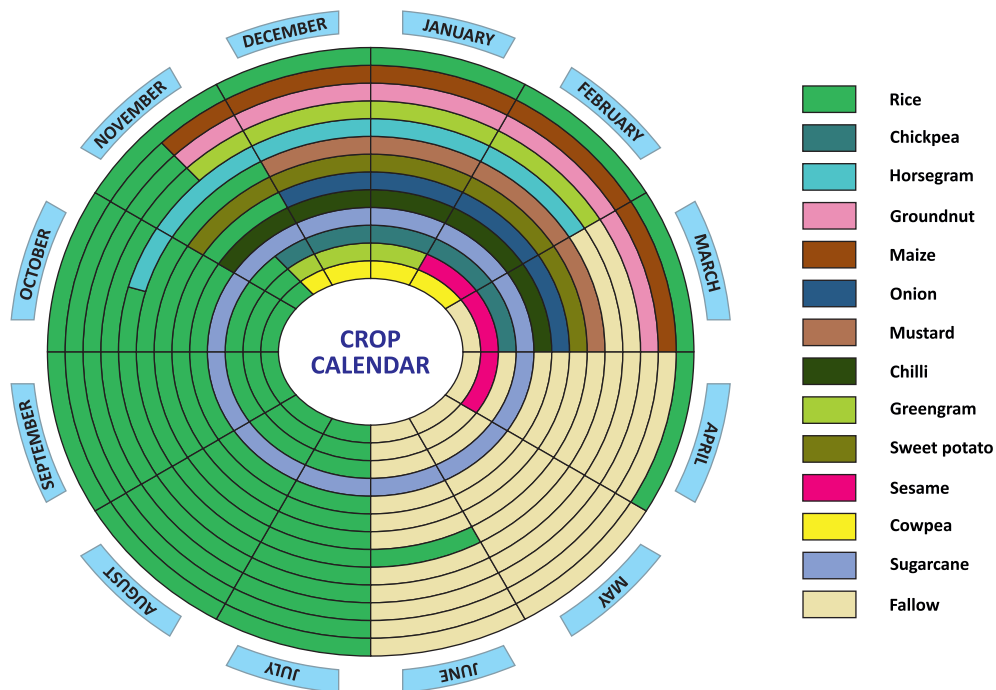


Fig 14. Crop calendar of South eastern ghat zone for irrigated situation

Table 7: Rice crop calendar for South eastern ghat zone

Rice ecology/ Wet season	Crop Estab- lishment	January	February	March	April	May	June	July	August	September	October	November	December
Rainfed Upland	DSR												
Irrigated upland	DSR												
Rainfed medium land	DSR												
Rainfed medium land	TPR												
Irrigated medium land	DSR												
Irrigated medium land	TPR												
Rainfed shallow lowland	DSR												
Rainfed shallow lowland	TPR												
Irrigated shallow lowland	DSR												
Irrigated shallow lowland	TPR												
Rainfed semi deep	DSR												
Rainfed semi deep	TPR												
Irrigated semi deep	DSR												
Irrigated semi deep	TPR												
Dry season													
Medium/shallow lowland	TPR												
Medium/shallow lowland	Wet DSR												
Medium/shallow lowland	SRI												

DSR - Direct Seeded Rice; TPR - Transplanted Rice; SRI - System of Rice Intensification
 Sowing window in Nursery (Yellow) Sowing window in main field (Orange) Transplanting window (Brown) Crop growth period (Green) Harvesting period (Light Green)

(viii) Western undulating zone agro climatic zone:

Kalahandi and Nuapada districts comes under Western undulating zone agro-climatic zone. The zone experiences warm and moist climate with mean annual rainfall of 1527 mm, having mean maximum summer temperature of 37.8 °C and mean minimum winter temperature of 11.9 °C. Nagabali, Indravati and Vansadhara river basins influences the crop production and civilization of the region. Broad soil groups of the region are red, black, mixed red and black. Irrigation ratio of the region is 29.4%. Based on topography the land type varies from unbunded upland to shallow lowland.

Rice is the principle food crop grown in three distinct seasons (autumn, *kharif* and *rabi*). Upland autumn rice is grown in substantial area under rainfed regions of Nuapada and Kalahandi. Khandagiri, Parijat, Anjali, Sahabthagidhan, Ananda drought tolerant varieties are popular in drought prone areas. Early medium and medium duration varieties like CR Dhan 100, CR Dhan 101, Binadhan 11, DR dhan 45, Naveen, CR Dhan 310 are recommended for medium land. CR Dhan 202, CR Dhan 205, CR Dhan 206 etc. are suitable aerobic rice for irrigated medium land. Ajaya, Rajlaxmi, Maudamani, Swarna, Pratikshya, Lalat etc. are suitable under shallow low land. Indravati, Mahanadi and CR Dhan 801 are suitable for lowlands. Besides rice, crops such as ragi, maize, small millets, blackgram, redgram and cotton are grown in substantial area under rainfed condition during wet season and wheat in dry season. Rice-maize, rice-green gram, rice-black gram, rice-chickpea, rice-field pea, rice-lentil, rice-horse gram, rice-groundnut, rice-sesame, rice-sunflower, rice-mustard and rice-onion are major cropping systems followed in the agro-climatic zone.

The climatic condition, rainfall pattern, irrigation sources, soil type, topography and market demand decides the selection of crop, sowing time, cropping pattern of agro-climatic zone. Rain fall pattern, availability of work forces, energy sources and socio economic condition of the farmers influences the sowing window and methods of crop establishment of a particular region. Indravati, Nagabali and Vansadhara irrigation projects facilitated multiple cropping in the command area. Drought, floods, soil acidity in wet season and cold stress in *rabi* season influences the crop production in the region. Based on ecology, safe crop growing period and local demands, the crop and crop calendar for different cropping systems of the Western undulating zone agro climatic zone are presented in Fig 15, 16. Based on the establishment methods, sowing/ planting windows and ecology, the crop calendar of rice is presented in Table 8.

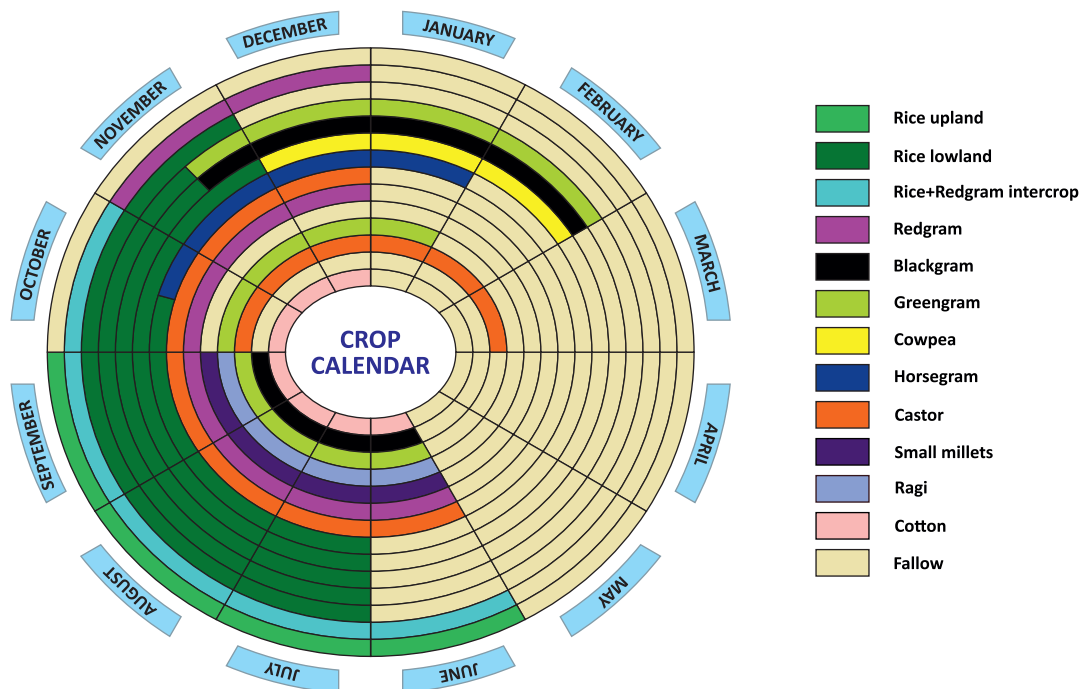


Fig 15. Crop calendar of Western undulating zone for rainfed situation

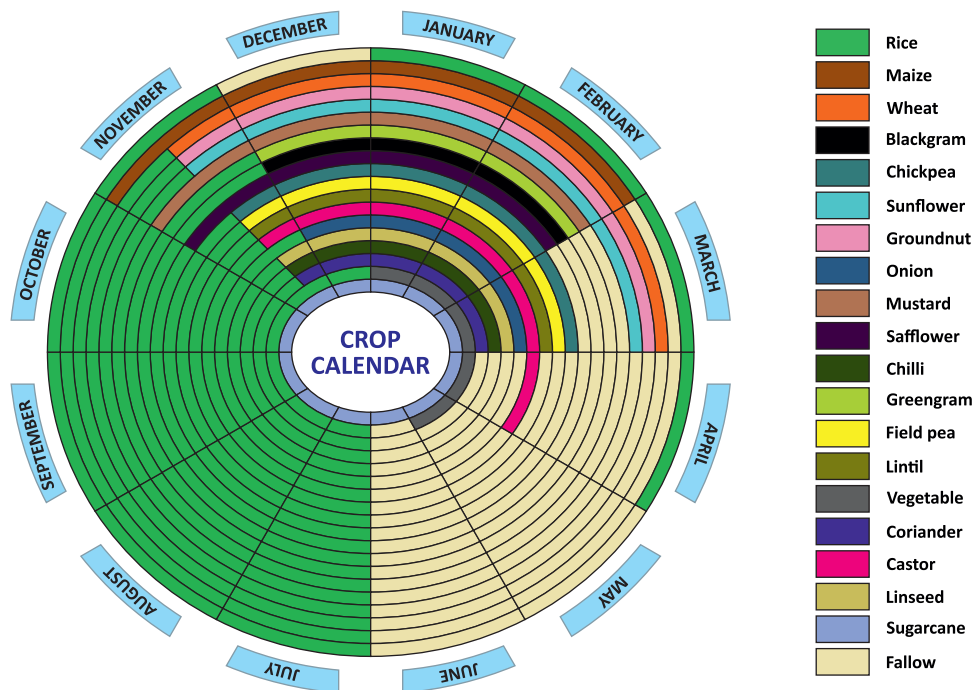


Fig 16. Crop calendar of Western undulating zone for irrigated situation

Table-8: Rice crop calendar for Western undulating zone

Rice ecology/ Wet season	Crop Establishment	January	February	March	April	May	June	July	August	September	October	November	December
Rainfed Upland	DSR												
Irrigated upland	DSR												
Rainfed medium land	DSR												
Rainfed medium land	TPR												
Irrigated medium land	DSR												
Irrigated medium land	TPR												
Rainfed shallow lowland	DSR												
Rainfed shallow lowland	TPR												
Irrigated shallow lowland	DSR												
Irrigated shallow lowland	TPR												
Rainfed semi deep	DSR												
Rainfed semi deep	TPR												
Irrigated semi deep	DSR												
Irrigated semi deep	TPR												
Dry season													
Medium/shallow lowland	TPR												
Medium/shallow lowland	Wet DSR												
Medium/shallow lowland	SRI												

DSR - Direct Seeded Rice; TPR - Transplanted Rice; SRI - System of Rice Intensification
 Sowing window in Nursery: Sowing window in main field: Transplanting window: Crop growth period: Harvesting period:

(ix) Western central table land agro-climatic zone

Bolangir, Baragada, Boudh, Sonepur, Sambalpur and Jharsuguda districts of Odisha come under Western central table land agro-climatic zone. The zone experiences hot and moist climate with mean annual rainfall of 1527 mm, having mean maximum summer temperature of 40.0 °C and mean minimum winter temperature of 12.4 °C. Mahanadi and Brahmani river basin mostly influences the agriculture production systems of the agro-climatic zone. Broad soil groups of the region are red and yellow, red and black, black, brown forest and lateritic. Irrigation ratio of the region is 38.8%. Land types varies from uplands to shallow low land.

Rice is the principle food crop grown in three distinct seasons (autumn, *kharif* and *rabi*) and considered as rice bowls of Odisha. Upland autumn rice is popularly known as *bialidhan* grown in substantial area under rainfed condition. Short duration varieties like Kalinga III, Khandagiri, Parijat, Anjali, Vandana and Ananda etc. (drought tolerant varieties) popular in the ecosystem. Early medium and medium duration varieties are like CR Dhan 100, CR Dhan 101, Binadhan 11, DR dhan 45, Naveen, CR Dhan 310 are recommended for medium land. CR Dhan 202, CR Dhan 205, CR Dhan 206 etc. are suitable aerobic rice for irrigated medium land. Ajaya, Rajlaxmi, Maudamani, Swarna, Pratikshya, Lalat, Geetanjali etc. are suitable under shallow low land. Indravati, Mahanadi, Ramachandi, Utakalprava and CR Dhan 801 are suitable for lowlands. Summer rice is most common in Hirakud command area. Besides rice, crops such as ragi, maize, small millets, black gram, sesame and cotton are grown in substantial area under rainfed condition during wet season and wheat in dry season. Rice-rice, Rice-maize, rice-greengram, rice-blackgram, rice-chickpea, rice-field pea, rice-lentil, rice- horsegram, rice-groundnut, rice-sesame, rice-sunflower, rice-mustard and rice-onion are major cropping systems followed in the agro-climatic zone.

The climatic condition, rainfall pattern, irrigation sources, soil type, topography and demand decides the selection of crop, sowing time, cropping pattern of agro-climatic zone. Hirakud irrigation projects facilitated multiple cropping in the command area. Drought, flood and soil acidity in wet season and cold stress in *rabi* season influences the crop production in the region. Based on ecology, safe crop growing period and local demands, the crop and crop calendar for different cropping systems of the agro-climatic zone are presented in Fig. 17, 18 and Table 9.

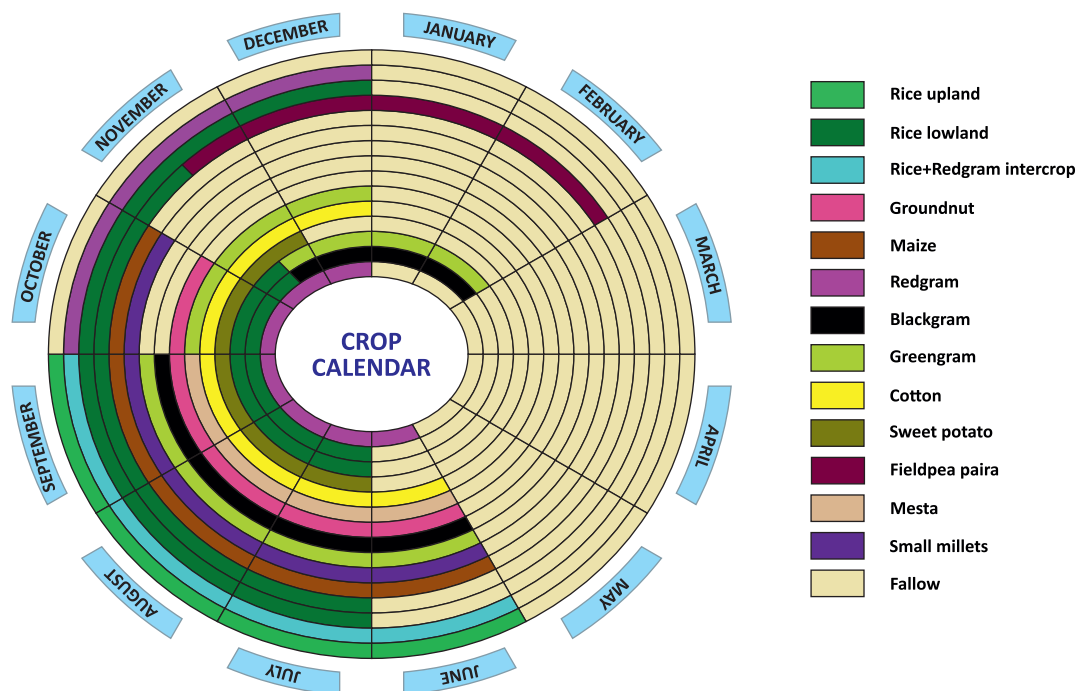


Fig 17. Crop Calendar of Western central table land zone for rainfed situation

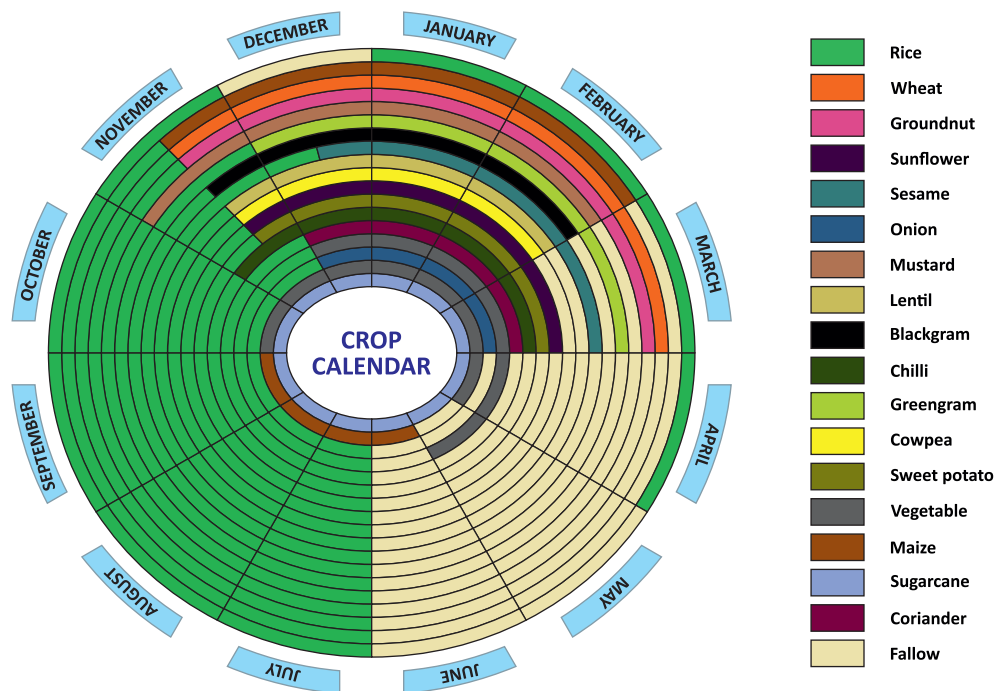


Fig 18. Crop Calendar of Western central table land zone for irrigated situation

Table 9: Rice Crop calendar for Western central table land

Rice ecology/ Wet season	Crop Estab- lishment	January	February	March	April	May	June	July	August	September	October	November	December
Rainfed Upland	DSR												
Irrigated upland	DSR												
Rainfed medium land	DSR												
Rainfed medium land	TPR												
Irrigated medium land	DSR												
Irrigated medium land	TPR												
Rainfed shallow lowland	DSR												
Rainfed shallow lowland	TPR												
Irrigated shallow lowland	DSR												
Irrigated shallow lowland	TPR												
Rainfed semi deep	DSR												
Rainfed semi deep	TPR												
Irrigated semi deep	DSR												
Irrigated semi deep	TPR												
Dry season													
Medium/shallow lowland	TPR												
Medium/shallow lowland	Wet DSR												
Medium/shallow lowland	SRI												

DSR - Direct Seeded Rice; TPR - Transplanted Rice; SRI - System of Rice Intensification

Sowing window in Nursery

Sowing window in main field

Transplanting window

Crop growth period

Harvesting period

(x) Mid central table land agro-climatic zone

Angul and Dhenkanal districts comes under mid central table land agro-climatic zone. The zone experiences hot and dry sub humid climate with mean annual rainfall of 1421 mm, having mean maximum summer temperature of 38.7 °C and mean minimum winter temperature of 14.0 °C. Broad soil groups of the region are red, lateritic, mixed red and black. Irrigation ratio of the region is 38.8%. Brahmani and Baitarani river basin enriches the agriculture of the zone. Hill plateaus are major land features of the region. Land type varies from unbunded upland to shallow lowland.

Rice is the principle food crop grown in two distinct seasons (*autumn* and *kharif* rice) during wet period. *Rabi* rice is gaining popularity in assured irrigated areas in some pockets of Angul and Denkanal district. Kalinga III, Khandagiri, Parijat, Ananda, Sahabhagidhan are popular in drought prone areas. Early medium and medium duration varieties like Binadhan 11, DR dhan 45, Naveen, CR Dhan 310 are recommended for medium land. CR Dhan 202, CR Dhan 205, CR Dhan 206 etc. are suitable aerobic rice for irrigated medium land. Ajaya, Rajlaxmi, Maudamani, Swarna, Pratikshya, Lalat etc are suitable under shallow low land. Indrāvati, Mohanadi, Utakalprava, Pooja are suitable for lowlands. Besides rice, crops such as maize, green gram, blackgram, redgram, groundnut, chillies, sweet potato are grown in substantial area under rainfed condition during wet season. Rice-maize, rice-greengram, rice-balckgram, rice-chickpea, rice-fieldpea, rice-horsegram, rice-groundnut, rice-sesamum, rice-mustard, rice-potato and rice-onion are major cropping systems followed in the agro-climatic zone.

The selection of crop, sowing time, cropping pattern of agroclimatic zone mostly influenced by local soil type, topography, and climatic condition. Brahmani and Baitarani irrigation project facilitated multiple cropping in the command area. Drought, acidity and heat stress in wet season and cold stress in *rabi* season influences the crop production in the region. Based on ecology, safe crop growing period and local demands the crop and crop calendar for different cropping systems of the agro- climatic zone are presented in Fig 19, 20. Based on the establishment methods, sowing/ planting windows and ecology, the crop calander of rice is presented in Table 10.

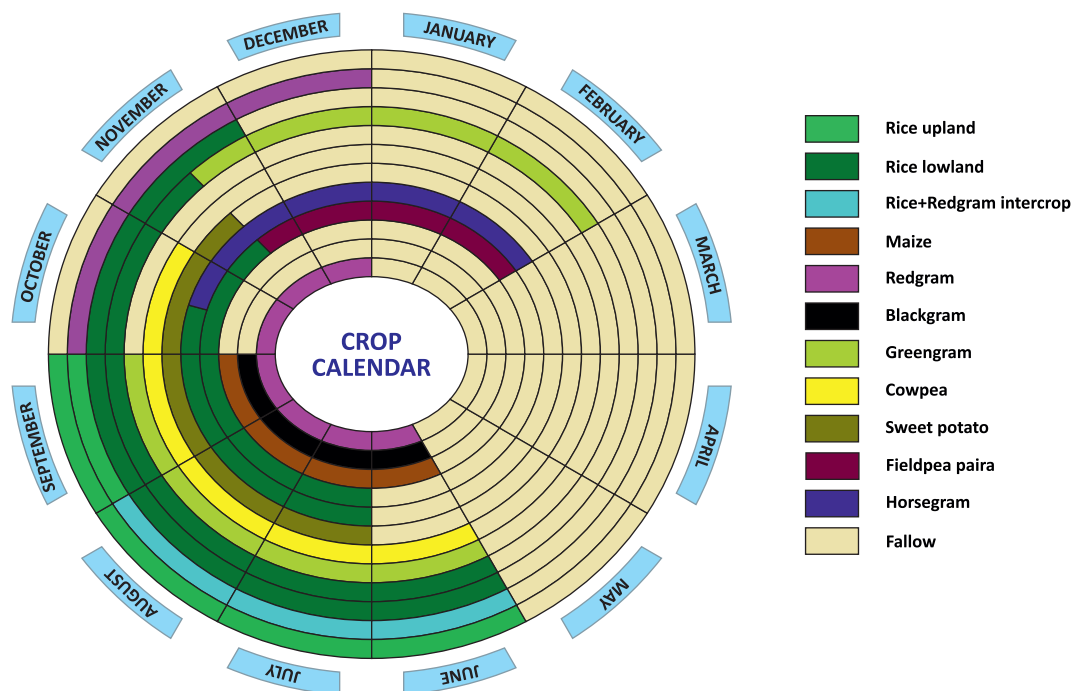


Fig 19. Crop Calendar of Mid-Central table for rainfed situation

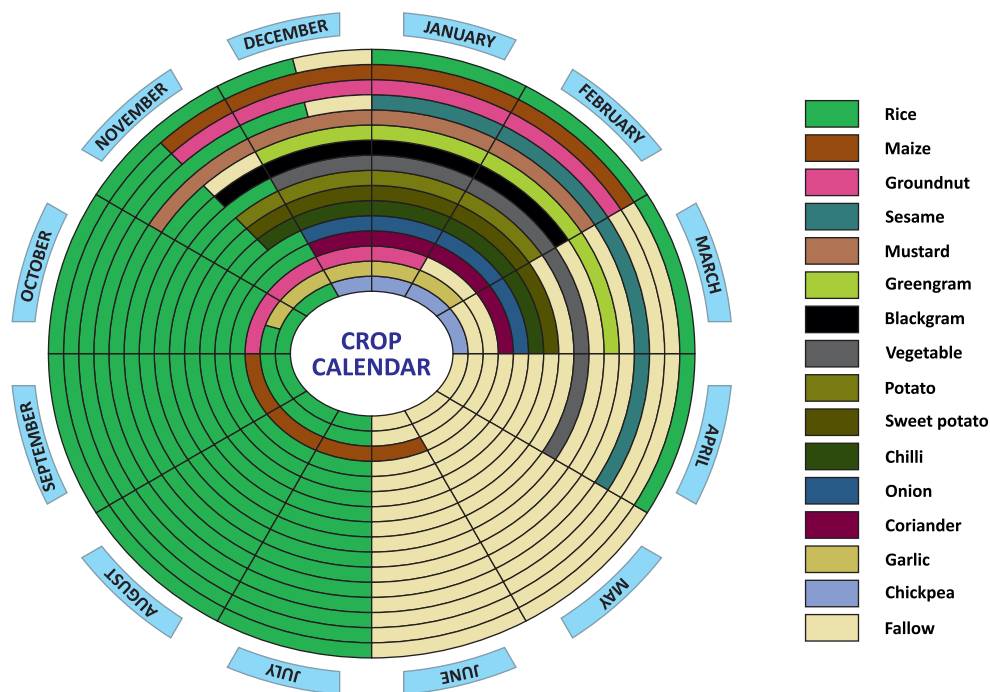


Fig 20. Crop Calendar of Mid-Central table for irrigated situation

Table 10: Rice crop calendar for Mid-central table land

Rice ecology/ Wet season	Crop Estab- lishment	January	February	March	April	May	June	July	August	September	October	November	December
Rainfed Upland	DSR												
Irrigated upland	DSR												
Rainfed medium land	DSR												
Rainfed medium land	TPR												
Irrigated medium land	DSR												
Irrigated medium land	TPR												
Rainfed shallow lowland	DSR												
Rainfed shallow lowland	TPR												
Irrigated shallow lowland	DSR												
Irrigated shallow lowland	TPR												
Rainfed semi deep	DSR												
Rainfed semi deep	TPR												
Irrigated semi deep	DSR												
Irrigated semi deep	TPR												
Dry season													
Medium/shallow lowland	TPR												
Medium/shallow lowland	Wet DSR												
Medium/shallow lowland	SRI												

DSR - Direct Seeded Rice; TPR - Transplanted Rice; SRI - System of Rice Intensification
 Sowing window in Nursery: Sowing window in main field: Transplanting window: Crop growth period: Harvesting period:

Conclusion

Soil type, climatic condition and food habits of people favours rice as the principle food crop of the state and grown in all ten agro-climatic zones in two distinct seasons under different ecologies. Maize, ragi, and millets are other cereals besides rice grown under different agro-climatic zones of Odisha. Pulses are the second most important food grain crop next to cereals followed by different oil seed crops. In addition to food grain crops, several cash crops like sugarcane, cotton, chilli, potato, sweet potato, yams, onion etc. are extensively cultivated in different regions of Odisha. Among the production practices rice-based production system is dominant in majority of the cultivated land across the various agro-climatic zones of Odisha. Rice-rice, rice-green gram, rice-black gram, rice-ground nut are major cropping systems spreads in all 10 agro-climatic zones of Odisha under both irrigated and rained ecologies. Prevailing long safe growing period in different agro climatic zones and ecologies favours multiple cropping with a great scope for enhancing cropping intensity. Judicious selection of crop and cropping system is pre requisite to sustain the crop production and higher input use efficiency by conserving the natural resources with minimum impact on environment in a particular agro-climatic zone. The sound knowledge of sowing windows and harvesting time of different crops under different cropping systems, ecologies of different agro-climatic zones of Odisha will helpful for optimum use of natural resources like land, water, sunshine, manpower etc. in agriculture with higher productivity which will help to enhance the farmer's income.

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