SUSTAINABLE LIVELIHOODS THROUGH TUBER CROPS-BASED AGRI-FOOD SYSTEMS

(Biennial Report of Tribal Sub-Plan 2022-24)

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(भारतीय कृषि अनुसंधान परिषद)
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FOREWORD

(G. Byju)
Director

From the Director

Tuber crops are the third most important food crop after cereals and grain legumes. It has special niche in tribal food system. The most important tuber crops are sweet potato (*Ipomoea batatas*), greater yam (*Dioscorea alata*), taro (*Colocasia esculenta*), elephant foot yam (*Amorphophallus paeoniifolius*), cassava (*Manihot esculenta*), yam bean (*Pachyrhizus erosus*) and arrowroot (*Maranta arundinacea*) etc. During 2022-2024, the Regional Station of ICAR-CTCRI, Bhubaneswar under Tribal Sub-Plan (TSP), demonstrated tuber crops technologies in 750 tribal farmers fields. Under TSP, the Centre has distributed 20000 kg quality planting materials of greater yam tubers, 16500 kg elephant foot yam corms, 9400 kg taro cormels, 500 kg yam bean seeds, 30.0 lakh sweet potato vine cuttings and 18000 stems (90000 sett) of cassava free of cost to the tribal farmers. Under this project, backyard poultry 5420 numbers were also distributed to the tribal farmers for improving their livelihood. Seeds of cereals maize (50 kg) and vegetables seed (450 kits and 125 kg) were also distributed to include in their farming system to achieve food and nutritional security. Farmers have contributed rice (548 kg), ragi (110 kg) and maize (60 kg) for farming system demonstrations. During the year 2022-24, a total of 136.66 ha was covered with tuber crops demonstrations. High yielding varieties of tuber crops were demonstrated in 63.66 ha whereas tuber crops based-farming systems were demonstrated in 73.0 ha.

Dr. M. Nedunchezhiyan, Principal Scientist of the Regional Station of ICAR-CTCRI, Bhubaneswar successfully led the TSP project for the past two years (2022-23 and 2023-24) and other scientists supported him to spread tuber crops technologies in tribal areas of Odisha and Andhra Pradesh. In this publication, two years (2022-23 and 2023-24) of demonstrations are given. The results of the TSP project indicated that sufficient tubers, cereals, millets, vegetables, meat, eggs etc. were made available for household consumption as well as selling for cash income with the inclusion of tuber crops in their cropping and farming systems. Thus, the outcome of the project clearly indicated that food and nutrition security and livelihood of tribal farmers improved in the project sites.

The information given in this publication is very useful to students, researchers and policy makers. I congratulate Dr. M. Nedunchezhiyan and his team for their sincere efforts in bringing out this highly useful publication.

(G. Byju)
Director

PREFACE

(M. Nedunchezhiyan)
Principal Scientist

Hills and plateau in Odisha and adjacent Andhra Pradesh are the dwelling places for the tribal people. In these remote, inaccessible disadvantaged locations tribals live their difficult life. They contain their life with available resources in their vicinity. Tribal agriculture is traditional and they cultivate cereals and millets. Though they have special niche for tubers but prefer to collect them from near by forest areas. Very few tribal farmers cultivate sweet potato and arrowroot. The Regional Station of ICAR-CTCRI, Bhubaneswar has developed nutritionally rich high yielding varieties of tuber crops which are suitable for tribal farming. Under 'Tribal Sub-Plan' (TSP), the Regional Station has popularized tuber crops technologies to tribal regions of Odisha and Andhra Pradesh to improve the livelihood of tribal farmers during 2022-2024. During this period, the Regional Station has given quality planting materials of tuber crops, vegetable seeds, poultry birds etc. free of cost to the tribal farmers and demonstrated the improved technologies for higher yield and nutrition. Through TSP, 750 tribal farmers were benefited. Tribal farmers were trained on scientific method of tuber crops cultivation by imparting training and exposure visits. Tribal youths and progressive farmers were also trained on processing and value addition of tuber crops at village level as well as at the 'Techno Incubation Centre', Regional Centre of ICAR-CTCRI, Bhubaneswar, Odisha.

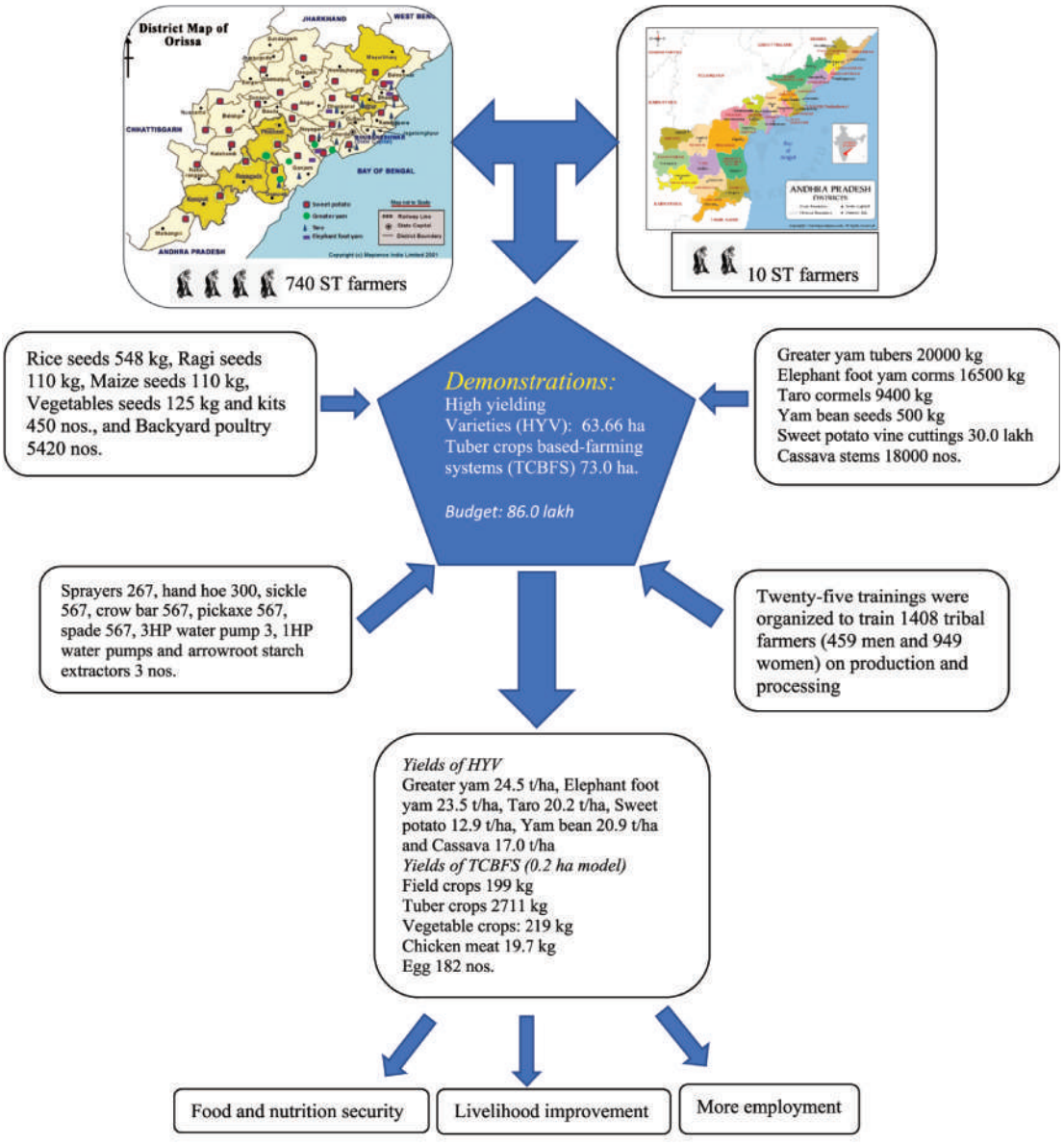
Scientists from ICAR-CTCRI, OUAT and officials of Directorate of Horticulture visited tribal farmers' fields and imparted training. This project was ably supported by then director of ICAR-CTCRI, Thiruvananthapuram Dr. M.N. Sheela as well as present director Dr. G. Byju.

NGOs PRASTUTEE and SOVA and KVK (OUAT) in Koraput, ORRISSA in Kandhamal, PREM, KVK (OUAT) and Directorate of Horticulture in Gajapati in Odisha, CWS in Rayagada district, KVK (OUAT), Baripada, MayurBhanj district and Utkalika Samiti in Jajpur helped in this project for conducting tuber crops demonstrations and training programmes.

In this publication, details of technologies demonstrated, input supply, training, yield of tuber crops and returns from location specific tuber crops-based farming systems and success stories were provided. Under TSP project, the income of the tribal farmer is doubled with the inclusion of tuber crops in cropping/farming system and has sufficient food for household consumption. Thus, food and nutrition security and livelihood improvement are achieved through tuber crops technologies.

(M. Nedunchezhiyan)
Principal Scientist

EXECUTIVE SUMMARY



Schematic diagram of TSP activities and out-come

ABBREVIATIONS

AAO	:	Assistant Agricultural Officer
AICRPTC	:	All India Co-ordinated Research Project on Tuber Crops
APICOL	:	The Agricultural Promotion and Investment Corporation of India
B:C	:	Benefit Cost
CHES	:	Central Horticultural Experiments Station
CIFA	:	Central Institute of Freshwater Aquaculture
CIP	:	International Potato Centre
CIWA	:	Central Institute for Women in Agriculture
CMD	:	Cassava Mosaic Disease
CTCRI	:	Central Tuber Crops Research Institute
DARE	:	Department of Agricultural Research and Education
DDG	:	Deputy Director General
DDH	:	Deputy Director of Horticulture
DG	:	Director General
Dist	:	District
DKVK	:	Divyayan Krishi Vigyan Kendra
DMV	:	Dasheen Mosaic Virus
EFY	:	Elephant Foot Yam
FLD	:	Front Line Demonstration
FYM	:	Farm Yard Manure
g	:	Gram
GP	:	Gram Panchayat
ha	:	Hectare
HEW	:	Horticultural Extension Worker
ICAR	:	Indian Council of Agricultural Research
IDM	:	Integrated Disease Management
IFAD	:	International Fund for Agricultural Development
IIHR	:	Indian Institute of Horticultural Research
IIWM	:	Indian Institute of Water Management
IPM	:	Integrated Pest Management
ISARA	:	Institute of Social Action and Research Activities
ISEC	:	Information Services and Extension Communication
JFS	:	Junior Farm Superintendent
KASAM	:	Kandhamal Apex Spices Association for Marketing
KIIT	:	Kalinga Institute of Industrial Technology
kg	:	Kilogram
KVK	:	Krishi Vigyan Kendra
MDMP	:	Mid-Day Meal Programme
NGO	:	Non-Government Organization
NHB	:	National Horticultural Board
NRRI	:	National Rice Research Institute
ORRISSA	:	Organization for Rural Reconstruction and Integrated Social Service Activities
OTELP	:	Odisha Tribal Empowerment and Livelihood Programme
OUAT	:	Odisha University of Agriculture and Technology
PI	:	Principal Investigator
PP	:	Plant Protection
PPR	:	Peste des Petits Ruminants
PPV&FRA	:	Protection of Plant Varieties and Farmers Rights Authority
PS	:	Principal Scientist
RKM	:	Rama Krishna Mission
RKVY	:	Rashtriya Krishi Vikas Yojana
Rs	:	Rupees
SACAL	:	Social Action for Community Alternative Learning
SMS	:	Subject Matter Specialist
SOVA	:	South Orissa Voluntary Action
ST	:	Schedule Tribes
t	:	Tonne
TIC	:	Techno Incubation Centre
TSP	:	Tribal Sub Plan
TSS	:	Total Soluble Solids
WHFO	:	World Health Food Organization

CONTENTS

1. Introduction

Tropical tuber crops are rich in carbohydrate and are a cheap source of energy. People living in in-accessible areas and disadvantaged locations mostly depend on tuber crops by gathering and cultivating. Tuber crops find special niche in tribal food habits. They play crucial role in food and nutritional security of the tribals. Sweet potato, cassava, yams, taro, elephant foot yam, arrowroot, yam bean etc. are coomonly cultivated and some-times collected from forest in tribal areas of Odisha (Nedunchezhiyan *et al.*, 2018a). The yield of tuber crops in the present production systems is very low especially sweet potato is <10.0 t/ha. Tuber crops are able to grow in different agro-climatic conditions and fit very well with different cropping systems and home stead gardens for year-round production (Nedunchezhiyan and Sahoo, 2019). No systematic effort was undertaken to improve the efficiency of these production systems by careful application of improved tuber crops technologies. Further, tuber crops are the main sources of energy and nutrients (fibre, calcium, iron and vitamins) and have health benefits such as antioxidative, hypoglycemic, hypocholesterolemia, antimicrobial, and immunomodulatory (Bansode *et al.*, 2021). A number of bioactive constituents such as phenolic compounds, saponins, bioactive proteins, glycoalkaloids, and phytic acids are rich in various tuber crops (Nedunchezhiyan *et al.*, 2018b and Nedunchezhiyan *et al.*, 2023). The Regional Centre of ICAR-CTCRI, Bhubaneswar has released vitamin-A rich sweet potato variety Bhu Sona (beta-carotene 14 mg per 100 g fresh tuber) and anthocyanin rich sweet potato variety Bhu Krishna (95 mg per 100 g fresh tuber). Tuber crops supply up to 24% of the energy required. These underground treasures offer tremendous opportunity for entrepreneurial initiative, employment generation and income from wide range of value-added products as food, feed, bio-fuel, pharmaceuticals, nutraceuticals and industrial starches, etc. Hence, the envisaged 'Livelihood improvement of tribal farmers programme' would focus more on outreach programmes complemented with need-based research modules which would be done through support of seed materials development and distribution, knowledge dissemination, production and processing linkage, capacity building and entrepreneurship development.

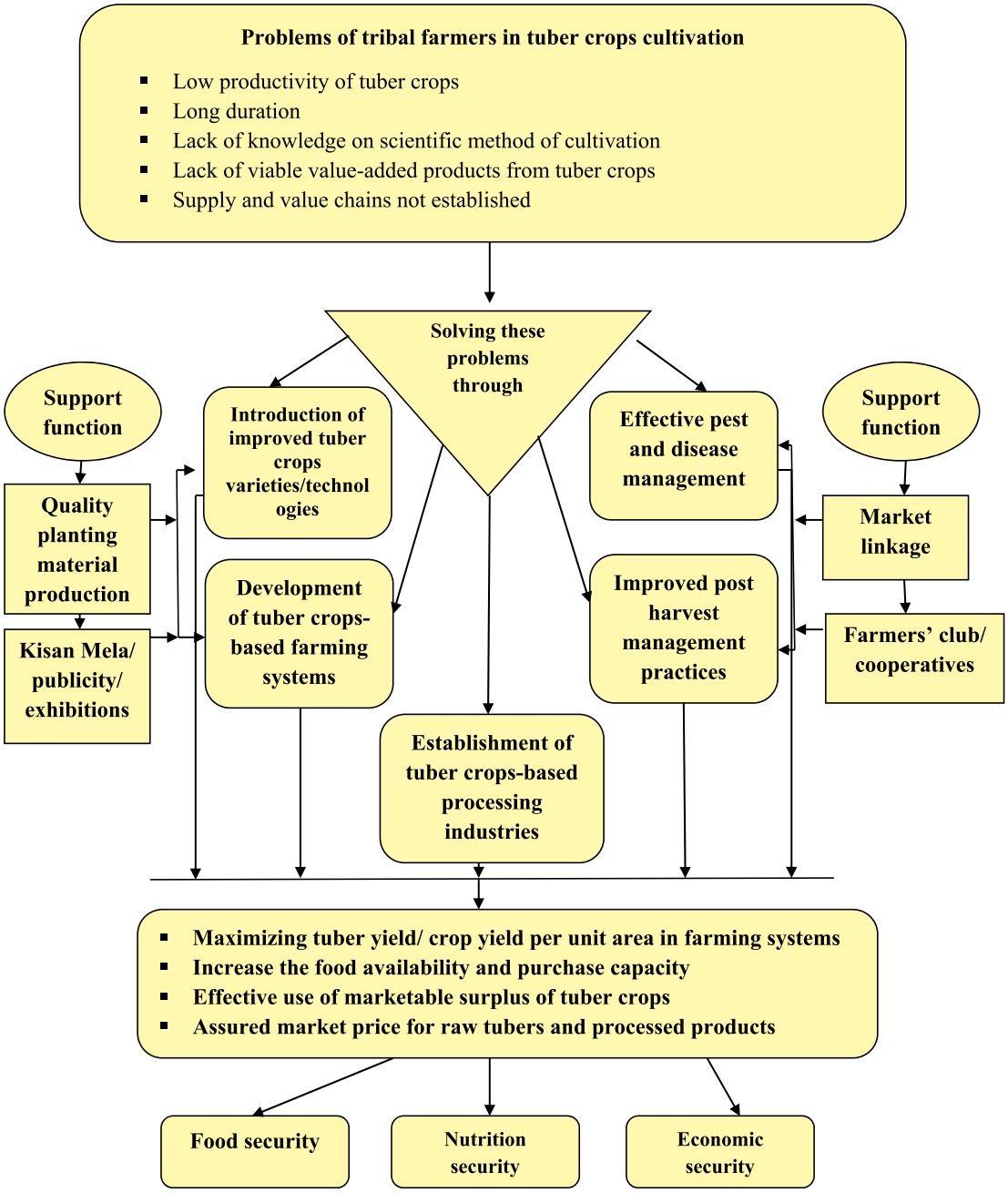
1.1. Objectives

The primary objective is to enhance livelihood security of tribal farmers by careful application of improved tuber crop production and processing technologies. The specific objectives are

1. Assessing existing level of awareness and utilization of tuber crops
2. Identifying and demonstrating appropriate tuber crops technologies
3. Capacity building of tribal farmers in tuber crops
4. Establishing tuber crops value addition Centres in potential areas

Assessing the impact of tuber crops technology interventions on food security, nutritional security and livelihoods of the tribal beneficiaries.

1.2. Conceptual framework



2. Locations

2.1. Odisha

Odisha is an eastern state of India comprised of hills and plateau, and coastal plain regions (Photo 1). Odisha has a geographical area of 1,55,707 sq. kms with a population of 4.19 crores. Agriculture is the main stay of state's economy and providing livelihood support to a large section of rural population. 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. About 84 per cent of the farmers are small and marginal and have limited access to resources. As per Agricultural Census-2010-11, the number of operational holdings of the state is 46.67 lakh with operational area 48.52 lakh ha.

The climate of the state is tropical, characterized by high temperature, high humidity, medium to high rainfall, short and mild winter. The normal rainfall in the state is 1451 mm, of which about 80% is confined to monsoon months (June-September). The state is divided into 10 agro-climatic zones, viz., North-western plateau, North-central Plateau, North-Eastern coastal plain, East and South-Eastern coastal plain, North-Eastern Ghat, Eastern Ghat high land, South-Eastern Ghat, Western undulating zone, West Central table land and Mid-Central table land. Soil types ranged from fertile alluvial deltaic soils in coastal plains, mixed red and black soils in Central tableland, red and yellow soils with low fertility in Northern Plateau to red, black & brown forest soils in Eastern Ghat region. Soils are mainly acidic with the degree of acidity varying widely.

Agriculture in the state is characterized by low productivity due to traditional agriculture practices by poor people, inadequate irrigation infrastructure, skewed land distribution, small size holding, low investment and capital formation and natural calamities like cyclone, flood and drought occurring in quick succession. Rice is the most important food crop of Odisha. Nearly 70% of the state's population directly or indirectly depends upon rice cultivation. It is grown in an area of 41.8 lakh ha with productivity of 1821 kg/ha (rice) during 2013-14. Pulses are the second most important group of crops next to cereals in Odisha. Maize, ragi, root and tuber crops are the other major food crops grown in the state.

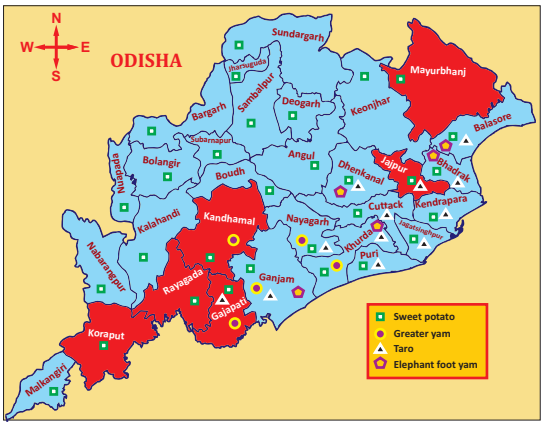


Photo 1. Odisha state

The most important tuber crops commonly cultivated in Odisha in the order of importance are sweet potato (*Ipomoea batatas*), greater yam (*Dioscorea alata*), taro (*Colocasia esculenta*), elephant foot yam

(*Amorphophallus paeoniifolius*), cassava (*Manihot esculenta*), yam bean (*Pachyrhizus erosus*) and arrowroot (*Maranta arundinacea*). Sweet potato is grown in 43460 ha with the production of 410100 tonnes (NHB, 2013). The productivity is 9436 kg/ha. Cassava is cultivated in 60 ha with the production of 990 tonnes (NHB, 2013). The productivity is 16500 kg/ha.

2.1.1. Koraput district

Koraput district is in southern Odisha, with headquarters at Koraput. The district is located in the eastern ghats and is known for its hilly terrain, rich and diverse types of mineral deposits and its tribal culture and traditions. Koraput district is located between 18^{0}13' and 19^{0}10' North Latitudes and 82^{0}5' and 83^{0}23' East Longitudes (Photo 2). Koraput comes under the 'Eastern Ghat Highland Agro climatic Zone'. It is composed of two separate plateaus at an average elevation of 3000 and 2000 feet respectively which are separated from each other and the surrounding plains by a ring of hills. Most of the hills have been denuded of forests due to generations of shifting cultivation. The rainfall averages approximately 160 cm and falls in the monsoon months of June-September. Most of the land is given over to the cultivation of rice, ragi and flax. The district overall has a warm and humid type of climate, though significantly more pleasant than the rest of Odisha. Mean maximum summer temperature is 34.1 ^{0}C and mean minimum winter temperature is 10.4^{0}C. The temperature on the 3000 feet plateau is often much lower and can approach close to freezing during peak winter at certain places.

According to the 2011 census, Koraput district has 50.60% Scheduled Tribes population. The district has one of the highest tribal populations in Odisha and is a Scheduled District under the Constitution of India. This prohibits sale and purchase of tribal land by non-tribals. As many as 51 different tribes have been noted in the undivided district. The largest tribe in the current district are the Parojas. The second largest community are the Khonds, who mainly live in the eastern mountains and have a population of 2 lakhs. Other major communities include the Bhottada, Gadaba and Bhumia.

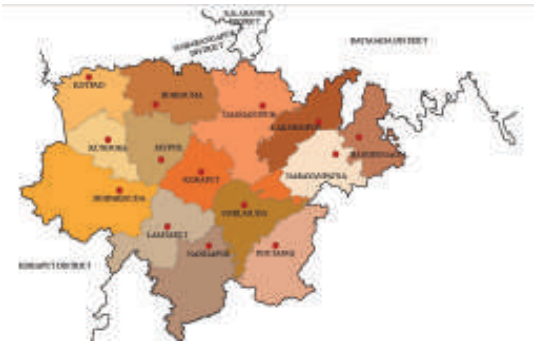


Photo 2. Koraput district

The district's economy mainly depends on agriculture and which mainly depends on rainfall. The rainfall depends on South-West monsoon. Out of total cropping area of 296000 ha in Koraput, irrigation potential in kharif is 30.71% and in rabi is 21.51%. During kharif, rice, maize, millets, sweet potato, greater yam, colocasia, cassava, arrowroot, ginger, turmeric

etc are grown widely. Generally, crops grown during rabi like rice, wheat, maize, ragi, mung, biri, groundnut, mustard, field pea, sunflower etc. needs assured irrigation. Jeypore tract of the Koraput district is known as one of the centres of origin of rice. The people of Koraput district, notably the adivasis have generated and conserved many indigenous cultivars of rice that are suitable for both dryland and wetland cultivation. The Food and Agricultural Organisation (FAO) in 2012 recognised the service of the communities of Koraput in ensuring food security by declaring the Koraput district as a 'Global Agricultural Heritage Site'.

2.1.2. Rayagada district

Rayagada district is a district in southern Odisha. It is located between 19^{0}10' and 19^{0}17' North Latitudes and 83^{0}25' and 83^{0}42' East Longitudes (Photo 3). The altitude is 687 feet above mean sea level. Its population consists mainly of tribes, primarily the Khonds and the Soras. Rayagada district has a population of 967911 (2011 Census of India), in which 57.52% Shedule Tribes. Agriculture is the chief source of income, and paddy, wheat, ragi, green and black gram, groundnut, sweet potato and maize are the district's major crops.

Photo 3. Rayagada district

2.1.3. Kandhamal district

Kandhamal district lies between 19^{0}34' and 20^{0}36' North Latitude and 83^{0}34' and 84^{0}34' East Longitude (Photo 4). Kandhamal experiences sub tropical hot and dry climate in summer. Dry and cold climate in winter. The maximum temperature recorded in the district is 45.5^{0}C and minimum temperature is 2.0^{0}C. The average annual rainfall recorded is 1522.95 mm. The Kandhamal district covering a geographical area of 7654 sq kms is bounded by Boudh district in the North, by Rayagada and Gajapati districts in the South, by Ganjam and Nayagarh districts in the East and Kalahandi District in the West. Physiographically, the entire district lies in high altitude zone with inter spreading inaccessible terrain of hilly ranges and narrow valley tracts, which guides the socio-economic conditions of people and development of the district. Almost 66 percent of the land area of the District is covered with dense forests and towering mountains rich in green meadows at the attitude of 2000 feet to 3000 feet. According to the 2011 census Kandhamal district has a population of 7,33,110 in which 53.58% Schedule Tribes. A majority of the inhabitants belong to the Kondh tribe.

The soil in the district is mostly red laterite group, having low organic matter content. As such, the water holding capacity is very low. The pH value of the soil varies 5.3 to 6.5, which is acidic in nature. The important crops grown in the district during kharif season is rice, maize and niger. During rabi, in irrigated areas, crops like potato, vegetable and mustard are grown. Rice is the primary staple food and crop of Kandhamal district. In recent years residents have focused on horticulture, sericulture, floriculture and other agricultural activities apart from rice. Mango, mahula (mahua), Indian gooseberry (amla), kendu, meswak and jackfruit are also found in abundance in the wilderness. Bamboo and Thysanolaena (broom grass) are collected from the forests of Kandhamal and used or sold. A special pulse known as kandula is native to this district; the Kondh people mostly cultivate it in the hilly forests. The organic turmeric cultivated in this district is popularly known as 'Kandhamal Haladi' and is renowned for its purity. An organization called Kasam promotes turmeric cultivation in the district. In some areas ginger is also cultivated along with turmeric.

Photo 4. Kandhamal district

2.1.4. Gajapati district

Gajapati district is a district of Odisha State. It located at the South-east of Odisha between Longitude 84^{0}32'E and 83^{0}47'E and Latitude 18^{0}44'N and 19^{0}39'N (Photo 5). The Mahendratanaya River flows through it. The district borders with Andhra Pradesh in the South, district of Rayagada to the West, district of Ganjam to the East and district of Kandhamala to the North. According to the 2023 census, Gajapati district has a population of 8,03,166 in which Scheduled Tribes make up 54.29%.

Photo 5. Gajapati district

The district is located on a hilly terrain of Eastern Ghats. The climate is subtropical with high humidity. The summer season is between March and mid-June and is extremely hot with the temperature reaching 46^{0}C. The winter season is mild and temperature can fall lowest to 9^{0}C November to February. The rainy season lasts between mid-June and mid-October and it receives approximately 1403 mm of rainfall primarily from the South-West monsoon. The soil and climate are suitable for plantation of crops and there is a great potential of horticulture development in the district. More than 60% of lands are situated in hilly terrain and high lands. Those are mainly suitable for horticulture. Other cultivable land is coming under medium lands (20%) and low lands (15%) category. Gajapati district gains a large amount of its revenue through the agricultural sector. Also, agro-processing and horticulture industries add to the economic wealth of this region. Economy of Gajapati district is agrarian in character. Except a few agro-processing units, there is no major industry in the district.

2.1.5. Jajpur district

Jajpur district is located in eastern Odisha. The district located in between 20^{0}30' and 21?^{0}10' North Latitude and 85^{0}40' to 86^{0}44' East Longitude (Photo 6). The district's average height from the sea level is 331 m. The district covering an area of 2887.69 sq km is moderately populated having total population of 18,26,275 as per 2011 census. Scheduled Castes and Scheduled Tribes made up 23.72% and 8.29% of the population respectively. The district is located on the Odisha coastal plain, with the southern part lying in the Mahanadi River Delta. To the north there are some small discontinuous hill ranges. Some of the major rivers in the district are the Brahmani and Baitarani on the eastern edge.

The climate of Jajpur district is subtropical with high humidity. Its average rain fall is 1014.5 mm. The average maximum and minimum temperatures are 38^{0}C and 12^{0}C respectively. Economy of the district is agrarian in nature. Agriculture and mining play dominant role in the economy of the district. Jajpur district is

Photo 6. Jajpur district

having the third best conditions for sustainable development in agriculture followed by Bargarh and Jagatsinghpur districts. The kharif rice is the main crop, covering over 85 percent of the total rice area, and depends entirely on the South-West monsoon. It is sown in June and harvested in October-December, depending upon the duration of the cultivation and topography of the field. The dalua (summer) crop coincides with the dry season and depends entirely on irrigation. The source of irrigation water is tank. The dalua season stretches from December-January to April-May. Farmers grow mung, biri, groundnut, vegetables, sweet potato etc. during this season.

2.1.6. Mayurbhanj district

Mayurbhanj district is in the Odisha state of eastern India. It is located between 21^{0}28' and 22^{0}08' North Latitudes and 86^{0}04' and 86^{0}37' East Longitudes (Photo 7). It holds the distinction of being the largest district in Odisha by area. As per 2011 census, Mayurbhanj ranks as the third-most populous district in Odisha, following Ganjam and Cuttack. Mayurbhanj is land-locked with a geographical area of 10,418 km^2 and lies in the North-East corner of the state. Scheduled Tribes make up 58.72% of the population respectively. The climate of Mayurbhanj is sub tropical marked by high humidity and rainfall during the Monsoon. The Simlipal Hills influence the weather substantially and exhibit higher rainfall and lower maximum temperatures than the rest of the district. The average annual rainfall is around 164 cm. Summer temperatures in Baripada can occasionally cross 45^{0}C but thunderstorms in the evening are common which have a moderating influence. Minimum temperature in winter can go down to 8^{0}C. Fog occurs occasionally during winters.

The western plains of Mayurbhanj are an extension of the Odisha Plateau. They are mostly flat with small hills and slopes but are at a higher altitude than the eastern plains, the

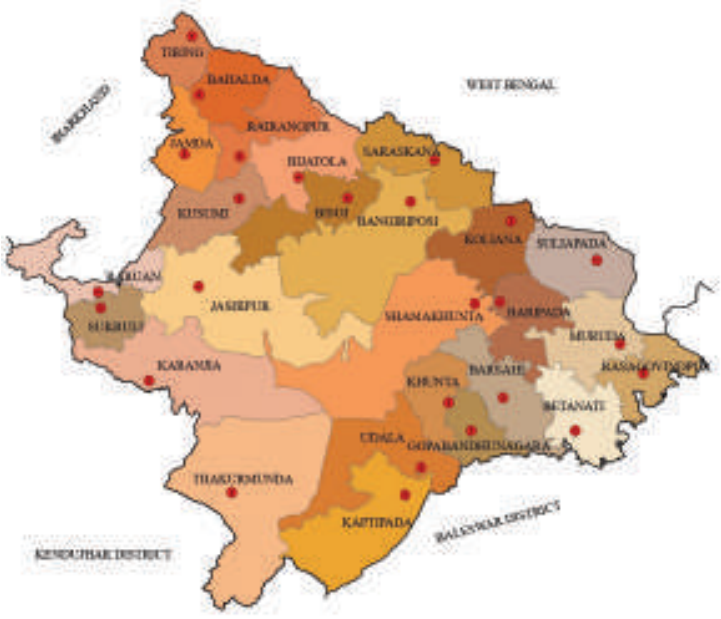


Photo 7. Mayurbhanj district

height rising from North to South. The streams here drain into the Baitarani River in Kendujhar or flow into Jharkhand to the North. There are still isolated open forests to be seen, but rice is the most common cultivated crop. The indigenous vegetation consisted of pure Sal forests which have now been replaced by rice cultivation.

2.2. Andhra Pradesh

Andhra Pradesh is a state in the southern coastal region of India. It is the seventh-largest state with an area of 1,62,970 km^2 and the tenth-most populous state with 4,95,77,103 inhabitants. It is located between 12^{0}41' and 19^{0}07' North Latitudes and 77^{0}00' and 84^{0}40' East Longitudes (Photo 8). The Eastern Ghats are a major dividing line separating coastal plains and peneplains. The coastal plains are part of Coastal Andhra. These are mostly delta regions formed by the Krishna, Godavari, and Penna rivers. Peneplains are part of Rayalaseema. 60% of the population is engaged in agriculture and related activities. Rice is the state's major food crop and staple food.

The climate varies considerably, depending on the geographical region. Summers last from March to June. In the coastal plain, the summer temperatures are generally higher than in the rest of the state, with temperatures ranging between 20 and 41^{0}C. July to September is the season for tropical rains from the South-West monsoon. During October to December, low-pressure systems and tropical cyclones form in the Bay of Bengal along with the North-East monsoon, bringing rains to the southern and coastal regions of the state. November to February are the winter months. Since the state has a long coastal belt, the winters are not very cold. The range of winter temperatures is generally 12 to 30^{0}C. Lambasingi in Visakhapatnam district is nicknamed the "Kashmir of Andhra Pradesh" as its temperature ranges from 0 to 10^{0}C). The normal rainfall for the state is 966 mm. Based on the 2011 Census of India, the

Photo 8. Andhra Pradesh state

population of Andhra Pradesh is 4,95,77,103, with a density of 304/km^2. The state has 5.53% Scheduled Tribe populations.

The agricultural economy comprises agriculture, livestock, poultry farming, and fisheries. 60% of the population is engaged in agriculture and related activities. Rice is the state's major food crop and staple food. The state has three agricultural export zones: the undivided Chittoor district for mango pulp and vegetables, the undivided Krishna district for mangoes, and the undivided Guntur district for chillies. Besides rice, farmers grow jowar, bajra, maize, minor millet, many varieties of pulses, oil seeds, sugarcane, cotton, chilli, pepper, mango, and tobacco. Crops used for vegetable oil production, such as sunflower and peanuts, are popular. The state contributes 10% of total fish production and over 70% of shrimp production in India. The geographical location of the state allows marine fishing as well as inland fish production. The most exported marine products include Vannamei shrimp.

2.2.1. Parvathipuram Manyam district

Parvathipuram Manyam district is a district in the Indian state of Andhra Pradesh. With Parvathipuram as its administrative headquarters, it became functional from 4th April 2022. The district was formed from Parvathipuram revenue division from Vizianagaram district and part of Palakonda revenue division of Srikakulam district. The district was once

Photo 9. Parvathipuram Manyam district

part of ancient Kalinga. It is located between 17^{0}15' and 19^{0}15' North Latitudes and 83^{0}00' and 83^{0}45' East Longitudes (Photo 9). As per 2011 census, the district had a population of 9,25,340 of which 86.6% live in rural areas. Scheduled Tribes make up 2,60,419 (28.14%) of the population in this district. Jatapus, Konda Dora, Savara, Gadabas, Manne Dora and Mukha Dora are the prominent tribes of this district. Rice is the staple food crop. Maize, millets, pulses, yams and sweet potato are the other crops cultivated in this district.

The Regional Centre of ICAR-Central Tuber Crops Research Institute, Bhubaneswar under Tribal Sub Plan has conducted demonstrations on tuber crops technologies along with cereals, pulses, vegetables, poultry etc. as integrated farming system in tribal areas of Koraput, Rayagada, Kandhamal, Gajapati, Jajpur and Mayurbhanj districts of Odisha and Parvathipuram-Manyam district of Andhra Pradesh.

3. Tuber crops technologies demonstrated

3.1. High yielding and biofortified varieties

3.1.1. Sweet potato

Variety

Bhu Sona: Spreading medium duration (110 days) orange fleshed variety, rich in beta-carotene (14 mg/100g fresh tuber weight) (Photo 10). Tuber yield 20-25 t/ha.

Bhu Krishna: High yielding, medium duration (110 days) and high anthocyanin (95 mg/100 g fresh tuber weight) variety with good cooking quality (Photo 11). Tuber yield 22-25 t/ha.

Kishan: Spreading medium duration (110-120 days) variety. High sugar and dry matter content variety. Tuber yield 17 t/ha.

Photo 10. Bhu Sona variety

Photo 11. Bhu Krishna variety

Climate and soil

Moderately warm climate and temperature of 21-26^{0}C is very conducive to sweet potato cultivation. A well distributed annual rainfall of 75-150 cm is favourable for its cultivation. Well drained loam and clay loam soils are good for sweet potato. Soil pH of 5.5-6.5 is appropriate for sweet potato.

Planting time

July is the best time of planting for rainfed crops especially hills and plateau. October-November is the best time under irrigated conditions in plains.

Planting material

In India, sweet potato is generally propagated by fresh vine cuttings, directly obtained from field. Vine cuttings (20-30 cm long) obtained from top and middle portions having 3-4 nodes are ideal for planting. If the planting material is sent to distance places defoliation is recommended.

Spacing and method of planting

The ridge and furrow method is helpful for convenient cultural operations, earthing up and economical water requirements. Vines are planted at a spacing of 20 cm on ridges of 45 cm height made 90 cm apart. Two cuttings per hill is recommended better establishment. The middle portion of the vine with nodes is buried 5-10 cm depth keeping both the ends exposed. About 85,000 cuttings are enough to plant one-hectare area.

Manures and fertilizers

For rainfed upland crop, farm yard manure 5 t/ha and N-P-K 50-25-50 kg/ha is recommended. Application of 5 t farmyard manure or compost and 75 kg/ha each of N and K and 50 kg/ha of P is recommended for the lowland *rabi* conditions. A full dose of P and half of N and K as basal dose at the time of planting and the remaining half 30 days after planting along with weeding and earthing up is recommended. Application of two-third recommended dose of N (26 kg/ha) and 2 kg *Azospirillum* to soil gives higher tuber yield.

Vine turning

Sweet potato establishes 10 days after planting. It starts growing vigorously after third week. It should be turned to avoid anchoring the soil at nodes 30 days after planting. This is essential to check vegetative growth and to enhance tuber yield. The turning of vines should also be done at the time of second weeding to check luxuriant growth.

Weeding

Weeding is essential for primary growth of sweet potato. The first weeding s carried out 30 days after planting followed by earthing up improves the physical condition of soil. The second weeding and earthing up should be done 60 days after planting.

Irrigation

In India sweet potato is mostly grown as a rainfed crop. If there is insufficient moisture irrigation may be given at 10-15 days interval.

Plant protection

Sweet potato weevil: Sweet potato weevil (*Cylas formicarius*) is the most important pest causing very severe damage to the crop. Adult weevil makes puncturing on vines and tubers. The grubs bore and feed by making tunnels. Even the slightly damaged tubers are unsuitable for consumption due to bitterness. Yield loss may go up to 100% in severe cases. On an average, 20-55% tuber loss occurs. The following integrated pest management was found effective against the weevil.

1. Dip the vine cuttings in fenthion or fenitrothion 0.05% solution for 10 minutes before planting.
2. Re-ridge the crop two months after planting.
3. Install synthetic sex pheromone traps @ 1 trap/100 m^2 area to collect and kill the male weevils.
4. Destroy the crop residues after harvest by burning.

Harvesting and yield

Harvesting sweet potato in 120 days after panting is recommended. Delay in harvesting invites attack of sweet potato weevil. Maturity is indicated when the leaves turn yellow and begins to fall. By cutting tubers and verifying that latex dries up without turning black indicates its maturity. For easing operation, light irrigation is given 2-3 days before digging of tubers. Care should be taken to avoid injuries and bruises on tubers. By adopting recommended varieties and improved cultural practices a yield up to 20 t/ha may be obtained

3.1.2. Greater yam

Variety

Orissa Elite: It is a short duration (6-7 months) variety twining right-side. Stem is green colour with emerging leaf is light brown. Field tolerant to virus, *Cercospora* leaf spot, scale insects and mealy bugs. Tuber shape is long cylindrical with dark brown skin colour and white flesh colour (Photo 12). Tuber cooking quality is soft, non-sticky and excellent. Self-life of the tuber is 6-7 months. Tuber yield 25 t/ha.

Sree Nidhi: It is a long duration (9-10 months) variety twining right-side. Stem is green colour with emerging leaf is green. Tolerant to anthracnose. Tuber shape is long cylindrical with dark brown skin colour and white flesh colour (Photo 13). Tuber cooking quality is soft, non-sticky and excellent. Self-life of the tuber is 4-5 months. Tuber yield 30-35 t/ha.

Sree Neelima: It is a long duration (9-10 months) variety twining right-side. A high yielding variety with purplish flesh colour, good culinary and nutritive quality (Photo 14). It has anthocyanin 15-50 mg/100 g fresh weight basis. It has high protein (15.37% on dry weight basis) and medium drymatter (24.6%), starch (18.1% fresh weight basis) content. It has high potassium (1.14%), Fe (70.80 ppm), manganese (7.20 ppm), zinc (49.80 ppm) and calcium (820 ppm) content. Tuber yield 35 t/ha.

Photo 12. Orissa Elite variety

Photo 13. Sree Nidhi variety

Photo 14. Sree Neelima variety

Climate and soil

Yams require temperature of 26-31^{0}C for better growth. A well distributed rainfall of 1100 mm is enough for their growth. Fertile sandy loam soil is ideal for growing yams. Loose, deep soil with high organic matter content and having pH of 5-7 is most suited for yams. Yams cannot sustain water-logging. Since they are long duration crops, they prefer soils rich in K content. In kitchen and homestead gardens, yams receive lot of ash, which is rich in K content.

Planting time

May-June is ideal time for rainfed crops in easter India.

Planting material

Yams are commonly propagated vegetatively. Tuber pieces or small whole tubers are used. Tuber pieces or whole tubers weighing 200-250 g are used for planting. Usually, big whole tuber is cut into pieces (setts) consisting of top, middle and bottom. Seed tubers and top portions are ideal for planting. Before planting, tuber pieces are dipped in cow dung slurry and dried in shade to protect from damage. Drying of cut pieces gives healing effect, encouraging callus formation.

Spacing and method of planting

Since greater yam has luxuriant growth and broad leaves, it requires spacing of 90 x 90 cm. Ridge and furrow method of planting is easy to harvest.

Mulching

Mulching helps protecting the propagating material from excessive soil temperature. It also helps in uniform sprouting and suppressing weeds. Dried farm waste can be used as mulch materials.

Manures and fertilizers

Farmyard manure or compost 10 t/ha should be incorporated in the soil. Application of N-P-K 80-60-80 kg/ha is recommended Total quantity of P and half of N and K should be given at the time of first weeding. The remaining N and K should be given after second weeding.

Weeding

Greater yam needs 3 weedings. Weeding 30, 60 and 90 days after planting is recommended Weeding is followed by earthing up is very important for maintaining ridge height.

Staking

Staking plays a crucial role in effecting higher tuber yields. As soon as yam vine emerges it tends to on climb any available support. In the absence of available support, the yam vines would simply lie on the ground. Failure to stake yams has been reported to cause drastic yield reduction. Bamboo or wooden twigs staking is recommended. Individual staking, pyramidal staking and trellising are different methods of staking is followed.

Irrigation

Yams are relatively tolerant to drought. However, yield is affected if moisture stress is faced during initial stages of growth. For uniform sprouting yams should be irrigated immediately after planting. Once the rain starts, there is no need of irrigation. However, proper moisture is beneficial. Care should be taken to avoid stagnation of water.

Plant protection

Yam scale is found to occur on the tubers both field and storage conditions. As a prophylactic measure, dip the planting material in imidacloprid 0.03%. and use scale free seed tuber for planting.

Harvesting and yield

Yams are harvested 7-9 months after planting. The leaves turn yellow and vines start drying up at maturity. Delaying in harvesting up to 2 months does not affect yield. Greater yam yields 30-40 t/ha.

3.1.3. Elephant foot yam

Variety

Gajendra: It is a short duration variety and harvested 180-210 days after planting. It is suitable for both kharif and rabi season. The variety produces smooth corms, free from

daughter corms (Photo 15). The cooking quality is very good low acridity (calcium oxalate 0.03 mg/100 g fresh tuber). It contains beta-carotene 2412 IU. Tuber yield 42 t/ha.

Photo 15. Gajendra variety

Climate and Soil

Elephant foot yam requires warm weather with a temperature of 25-35^{0}C. Humid conditions favour leaf growth in the beginning, whereas dry weather is favourable for corm development. Well distributed rainfall of 1000-1500 mm promotes better growth and corm yield. Well drained sandy loam soil is best suited for its cultivation. This crop can also be grown in soils with high clay and silt soils by incorporated with organic matter or compost to make the soil friable and light. Water-logging is harmful at any stage of crop growth.

Planting material

Elephant foot yam crop is propagated through corms and cormels. For commercial cultivation, whole or cut corms weighing 500-1000 g are used for planting. Whole corm is preferred over cut corm. Seed treatments are essential when cut corms are used as planting material to minimize rotting. Dipping of planting material in thick cow-dung slurry (2 kg

of fresh cow-dung in 1 litre of water) mixed with *Trichoderma* @ 5 g per kg of FYM followed by drying (24 hours) in a shaded place is effective in enhancing the sprouting.

Spacing and method of planting

Spacing depends on the weight of planting material. Planting seed corms weighing 500 g, a spacing of 90 x 90 cm is recommended. Corm setts can be planted eight ridge and furrow system or pit followed by mounds depending up on the soil type. In alluvial and black (clay loam) soils ridges and furrows are made. On the ridges, 5-10 cm below the soil elephant foot yam corm sett is planted. Corm sett planting is done vertically in the pits/ ridges.

Time of planting

March-April is the best period for planting in Odisha under irrigated conditions. As a rainfed crop it should be planted in May-June with the onset of rains.

Manures and fertilizer

Under rainfed conditions of Odisha, FYM 10 t/ha and N-P-K 80-60-80 kg/ha is recommended. However, under irrigated conditions FYM 10 t/ha and N-P-K 120-60-120 kg/ha is recommended. At the time of planting full dose of P and half of N and K are applied in pits. The remaining dose of N and K is applied around the shoots 30 and 60 days after planting at the time of weeding and earthing up.

Mulching

Immediately after planting, the crop should be mulched for 3-4 weeks. Paddy straw is generally used for mulching. Mulching helps in reducing soil temperature and conserve soil moisture besides enriching the soil and reducing weeds. Black polythene and water hyacinth can also be used for mulching.

Weeding

Elephant foot yam is susceptible to weed growth through-out the crop growth period because of less coverage of field by the leaf canopy. Hand weeding is the most common method of weed control. Hand weeding at 30, 60 and 90 days after planting is recommended. Each weeding is followed by earthing up. Pre-emergence application of pendimethalin or oxyfluorfen @ 1 kg/ha controls the weeds at early stage very effectively.

Irrigation

The crop should be irrigated lightly immediately after planting to get uniform sprouting. Subsequent irrigation before monsoon can be given depending on the requirement. Post monsoon irrigation leads to longer crop duration and higher yields. Care should be taken to avoid water stagnation in the field. Before harvesting, a shallow irrigation helps in easy digging of corms.

Plant protection

Collar rot

Collar rot is the most common disease, and prevalent in all elephant foot yam growing areas. It is caused by *Sclerotium rolfsii* Sacc. The most important symptoms are water-soaked lesions on the stem, yellowing at the tip of leaves which moves downward and collapse of stem due to rotting at collar region. It causes 20-100% yield loss. It can be controlled following crop rotation for 2-3 years, field sanitation and if necessary, drenching the soil around the plant with 0.2% captan or 0.5% benzimidazole or saaf/sixer 0.2%. Seed corm treatment with cow-dung slurry incorporated with *Trichoderma* (100 g in 20 kg FYM) is highly effective.

Leaf blight / Leaf rot

Leaf blight/leaf rot is more common in highly humid and warm areas. Leaf blight is caused by *Phytophthora colocasiae* Racib. Symptoms of leaf blight are generally observed in lower leaves. Small water-soaked lesions develop on the leaflets. These spots coalesce, enlarge and give rise to a blighted appearance. It can be controlled following crop rotation for 2-3 years, field sanitation and if necessary, drenching the soil around the plant with 0.2% captan or 0.5% benzimidazole or saaf/sixer 0.2%.

Dasheen mosaic virus (DMV)

DMV is not lethal; but its chief effect is to retard plant growth and reduce corm yield. The mosaic-infected plants are generally dwarfed and chlorotic in appearance and exhibit mosaic mottling which is more pronounced in young leaves. The leaflets become narrow and symptoms of leaf distortion like leaf strapping, rat tailing/shoe stringing, puckering and upward curling of leaf lamina are prominent in severely infected plants. However, in case of mild infection the yellowing and vein clearing symptoms are more common. Several aphid species are involved in disease transmission.

Management of field diseases of elephant foot yam

In elephant foot yam, diseases cause serious yield losses. The following integrated disease management evolved at CTCRI has been found very effective for managing the major field diseases of elephant foot yam.

- Use of healthy planting material with no symptoms of corm rot and obtained from mosaic-free plants.
- Mulching with dry paddy straw/plant leaves or black polyethylene sheets.
- Corm treatment with cow-dung slurry mixed with *Trichoderma* before planting.
- Application of *Trichoderma* enriched compost in pits before planting.
- Two preventive sprayings with Mancozeb (0.2%) + Imidacloprid (0.03%) at 60 and 90 days after planting.

Harvesting and yield

Elephant foot yam is harvested 6-7 months after planting under North Indian conditions, whereas in South India, it is harvested 9-10 months after planting. The maturity is indicated by yellowing and dropping of the leaves. The harvesting is generally done in November but it can be harvested earlier also, if there is a demand for vegetables during the off season. The lower yield due to early harvesting can be compensated by higher market price. If the soil is very hard, a light irrigation may be given before harvesting. Yield of 40-50 t/ha can be obtained depending upon the corm size used for planting and management practices adopted.

3.1.4. Taro

Variety

Muktakeshi: It is a 6-7months duration variety. Plant is erect and medium tillering. Leaves are narrow with green colour petiole. Cormel is cylindrical with light grey skin colour and white flesh (Photo 16). The variety is tolerant to leaf blight and dasheen mosaic virus. Cormels are having excellent cooking quality and non-acrid. Cormel yield 20 t/ha.

Photo 16. Muktakeshi variety

Sree Telia: It is a short duration (4-5 months) variety. Plant is erect and medium tillering. Leaves are broad with pink/red petiole. Cormel is cylindrical with grey skin colour and white flesh (Photo 17). Cormels are having good cooking quality. Cormel yield 15-18 t/ha.

Sree Hira: It is a 6 months duration variety. Plant is semi-erect and medium tillering. Leaves are broad with green petiole. Cormel is elliptical with brown skin colour and white flesh (Photo 18). Cormels are 14-18 cm length. Cormels are having good cooking quality. Cormel yields 16-20 t/ha.

Photo 17. Sree Telia variety

Photo 18. Sree Hira variety

Climate and soil

Taro requires moist conditions. An annual rainfall of 700-1000 mm well distributed during growth period is required for optimum tuber yield. Well drained and fertile sandy loam soil is ideally suited for its cultivation. It also comes up well in fertile loamy to clay loam soil. It can stand well in heavy soils and withstand waterlogged condition. The pH of 5.5-7.0 is ideal

Planting material

Taro is propagated vegetatively mostly by small cormels weighing 20-25 g. Healthy disease and injury-free uniform sized planting material should be selected and stored in a cool place at least for 3 months before planting. One tonne planting material is enough for planting a hectare crop.

Spacing and method of planting

Land preparation till a fine tilth is very essential. A spacing of 60 x 30 cm is recommended for taro. Planting of cormels should be done at 30 cm spacing on ridges made 60 cm apart. Flat bed method can also be adopted under upland conditions having good drainage. Planting in small pits is good in flat bed planting. Mulching with leafy material reduces weed incidence, conserves moisture and increases tuber yield. the depth of planting of cormels varies between 5-10 cm. High planting density at a distance of 45 x 30 cm is also effective but its seed requirement is 1.5-2.0 t/ha.

Planting time

Rainy season is ideal time for planting, whereas February-March is for irrigated areas.

Manures and fertilizers

Farmyard manure or compost is recommended @ 10 t/ha along with N-P-K 80-60-80 kg/ha. Half dose of N and K and full dose of P should be applied as basal. The remaining N and

K is applied in 2 split doses, first 30 days after planting and second a month later. Earthing up should be done after each topdressing.

Weeding

Three hand weeding followed by earthing up at 30, 60 and 90 days after planting is recommended

De-suckering

De-suckering is done at the time of second earthing up. Only 3 suckers/plant should be allowed if the rainfall is not regular.

Irrigation

The kharif crop is grown under rainfed conditions, but protective irrigation should be given if the rainfall is not regular.

Harvesting and yield

The crop matures 120-150 days after planting. This is indicated by drying up of leaves. Harvesting is done by digging out the corms and cormels. The mother corms and cormels are separated before marketing. It yields 20-30 t/ha depending on variety.

3.1.5. Yam bean

Variety

Rajendra Mishrikand (RM-1): It is an early maturing (110-120 days) variety. Plants are having long spreading vine with yellowing green colour leaves. Tuber is fusiform in shape with thin creamy white skin and white flesh (Photo 19). Crop grown for tuber purposes are mostly free from pest infestation. Tuber yield 35 t/ha.

Photo 19. RM-1 variety

Climate and soil

Yam bean is adapted well in subtropical to humid, hot, temperate zones. It can be grown up to 1000 m above mean sea level. Heavy rainfall along with waterlogging conditions is unfavourable for its cultivation. But evenly distributed rain throughout the growth period is favourable for good tuber development. Cool temperature is favourable for good tuber development.

Sandy loam soil of good depth is favourable for its cultivation. The soil pH of 6.0-7.0 is ideal. The clay loam soil with good fertility and drainage is most suited for its cultivation.

Seed material

The propagation of yam bean is mainly through seeds. Sometimes tubers are used for planting in order to maintain desirable characteristics of plants but normally it is not practiced. Seeds are sown with the onset of monsoon. The seed rate varies according to spacing of the crop. A seed rate of 10-20 kg/ha is generally adopted by the farmers.

Sowing time

The seeds should be sown from June-September.

Spacing and method of sowing

Sowing on ridges at a spacing of 60 x 20 cm gives good yield. Sometime yam bean seeds are sown 2-3 seeds/hill.

Manures and fertilizers

Farmyard manure 10 t/ha should be applied at the time of land preparation. The fertilizer dose of N-P-K 80-60-80 kg/ha is recommended. Full P and half N and K are applied as basal at the time of sowing. The remaining half dose of N and K is applied as top dressing 30 days after sowing at the time of earthing up.

Weeding

Two weeding is required. First weeding is done 30 days after sowing followed by another after 30 days of first weeding. Straw mulching helps in better moisture conservation and also suppresses weed growth.

De-flowering

Normally yam bean starts flowering 75 days after sowing. It is desirable to remove the flowers without allowing the plants to bear pods for getting better tuber yield.

Irrigation

The rainfed crop sown in June-July does not require irrigation. In September sown crop it is advisable to give supplementary irrigation, so that crop does not face moisture stress during tuber formation.

Harvesting and yield

It can be harvested early or late according to market demand. It is possible to harvest the crop with smaller size tubers after 100 days. Otherwise, it can be left in the field up to 150 days for better size. Traditionally the trend is to harvest the crop on the occasion of 'Saraswati Puja' with the start of spring season because of market demand. Delayed harvests lead to fibrous flesh along with cracks in the tubers. This causes deterioration in tuber quality in the market. A light irrigation should be given to soften the soil before harvesting. First top vegetative part is removed then the tubers are dug manually. Care should be taken to avoid cuts and bruises on tubers. It yields 20-30 t/ha.

3.1.6. Cassava

Variety: Sree Jaya, Sree Vijaya

Sree Jaya: It is erect branching early maturing variety with good cooking quality (Photo 20). It is suitable to low land as a rotation crop susceptible to CMD. The crop duration is 210 days and yielding 26-30 t/ha.

Sree Vijaya: It is erect branching early maturing variety with good cooking quality (Photo 21). It is suitable to low land as a rotation crop susceptible to spider mites and scale insects. The crop duration is 210 days and yielding 25-28 t/ha.

Photo 20. Sree Jaya variety

Photo 21. Sree Vijaya variety

Climate and soil

Cassava grows well in warm and humid climate with well distributed rainfall. It can tolerate drought once it is established. It grows on all types of soil, but saline, alkaline and ill drained soils are not suitable.

Land preparation

According to the situation different methods are being followed. In light textured soil flat method of land preparation, in heavy textural soil mound method and under irrigated condition ridges and furrow method of land preparation is suggested.

Planting material and planting

While preparing the stakes it is better to have a smooth circular cut rather than an irregular cut for uniform callus formation and root initiation. A stake length of 25-30 cm is beneficial. Shallow planting facilitates production of more number of roots. When soil is sufficiently loose and friable, stakes can be planted to a depth of 5 cm. Cassava setts are planted in different methods like vertical (90 degrees to the ground), slanted (45 degrees angle) and horizontal. However, vertical planting results in more uniform formation of callus tissue around the cut surface which helps in uniform distribution of tuber forming roots all-round the base of the plant.

Time of planting

Under irrigated conditions cassava can be planted throughout the year. As a rainfed crop, the best time of planting is June with the onset of pre monsoon showers.

Spacing and plant population

Cassava genotypes are classified into branching, semi branching and non-branching types. Non branched types required 75 x 75 cm while semi branched and branched types require 90 x 90 cm for optimum yield.

The sprouts emerging from the top buds are more vigorous than those emerging from the lower nodes of the stake. Removal of excess sprouts by retaining 2/plant at opposite sides is better for the production of more number of tubers/plant.

Gap filling

Under field conditions, all the stakes planted may not establish due to poor quality planting material and adverse weather conditions. At the time of planting stakes in the main field about 5% of the stakes (600) may be planted separately at a very close spacing of 5 x 5 cm in a nursery (1 m^2) with pot watering so that the settings at the age of 20-25 days old may be uprooted and used for gap filling.

Weeding and earthing up

Three weeding is required at 30, 60 and 90 days after planting. Earthing up should be followed after weeding.

Manures and fertilizers

FYM/Compost 12.5 t/ha along with N-P-K 100-75-100 kg/ha is recommended. Full P and 1/3 N and K at basal. The remaining 2/3 N and K in two splits at 30 and 60 days after planting.

Water requirement

Cassava is mostly grown under rain fed situation. Sufficient moisture should be ensured in the field for the first twenty days after planting.

Plant protection

Cassava mosaic disease (CMD): It is caused by Indian cassava mosaic gemini virus. Chlorotic areas intermixing with normal green tissue gives mosaic pattern. In severe cases leaves are reduced in size, twisted and distorted, reducing chlorophyll content and photosynthetic area. It causes 25-80% yield reduction. The disease can be effectively managed by 1) using disease free planting material, 2) growing field tolerant varieties like H 97, H 165, Sree Visakham and Sree Sahya, 3) roguing-out infected plants and follow strict field sanitation and 4) keeping the fields free of self sown cassava plants which may serve as a source of inoculums and help the spread of disease. Prompt disposal of cassava residue is essential.

Tuber rot: It is caused by *Phytophthora drechsleri*. Infected tubers show brown discolouration of internal tissues, rotten and emit foul smell and unfit for consumption or marketing, causing heavy yield loss. The disease can be managed by 1) improving drainage, 2) removing infected tubers from the field and 3) incorporating *Trichoderma viridae* into the soil.

Harvesting and yield

The crop is ready 7-10 months after planting. Delay in harvesting may result in deterioration in cooking quality of the tubers. It yields 25-30 t/ha.

3.2. Resource use efficient production systems demonstrated

3.2.1. Greater yam+maize intercropping system

Maize was found suitable intercrop in greater yam cultivation (Photo 22). Greater yam is planted at 90 x 90 cm spacing in ridge and furrow system. In the intra-rows, between

Photo 22. Greater yam+maize intercropping system

two greater yam plant three maize plants are sown. Thus, maintaining spacing of 90 x 30 cm for maize. Both greater yam and maize has to plant/sown same time. Immediately after planting/sowing mulching farm waste 2 t/ha is recommended. FYM 10 t/ha is applied at the last plough, before forming ridges. Application of N-P-K @ 120-90-120 kg/ha is recommended for greater yam+maize intercropping. Basal dose full P and 1/3rd N and K. Remaining 1/3rdN and K at one month after planting and last 1/3rdN and K at two months after planting. At physiological maturity maize cobs are to be harvested. Greater yam uses haulms of maize for trailing. Thus, this intercropping system reduces cost of cultivation and replaces wooden/bamboo staking and produce additional maize yield. It is environmentally safe and economically viable, eco-friendly intercropping system.

3.3. Integrated disease management (IDM)

3.3.1. Taro leaf blight

Photo 23. Taro leaf blight

Leaf blight of taro, caused by Phytophthora colocasiae, is the most destructive disease of taro. Phytophthora blight of taro appears as small, water-soaked spots that increase in circumference and also spread to healthy plants (Photo 23). The entire leaf area is destroyed within few days. Under cloudy weather conditions with intermittent rains and temperature around 28oC, the disease spreads at tremendous speed and the entire field gives a blighted appearance. Yield losses of 25-50% are common due to this disease. The rainy season crop is damaged during its peak of crop growth.

Several methods for the management of leaf blight of taro have been recommended but the use of tolerant cultivars seems to be the most ideal and economical method. Many cultivars of taro tolerant to leaf blight have been reported from India. The varieties Muktakeshi and Sree Hira showed high degree of field tolerance to blight. A farmer's friendly IDM package for the management of the taro blight has been developed at ICAR-CTCRI. The package includes growing resistant variety like Muktakeshi/Sree Hira, short-duration variety with early planting, one protective spray with mancozeb (0.2%) at 45 days after

planting followed by one more spray with metalaxyl (0.05%) at 60 days after planting in susceptible cultivars, intercropping with non-host crops, use of disease-free seed tubers and seed tuber treatment with Trichoderma viride.

3.3.2. Elephant foot yam collar rot

Collar rot is the most common disease, and prevalent in all elephant foot yam growing areas. It is caused by *Sclerotium rolfsii*. This disease is generally observed in the later part of crop growth but the pathogen is capable of infecting the plants at any stage. The disease is more destructive during the rainy season followed by warm dry weather. The pathogen is soil borne. Injury to the collar region during intercultural operations acts as a predisposing factor for infection by *S. rolfsii*. As a result of invasion by the pathogen in the collar region, water-soaked lesions appear on the stem just above the soil surface and the leaf starts turning yellow from the tip (Photo 24). Yellowing gradually spreads downwards leading to the complete yellowing of the plant. Finally, the petiole (pseudostem) shrinks and the plant collapses due to rotting of the collar region causing heavy yield loss.

Photo 24. Elephant foot yam color rot

Cultural practices like removal of infected plant debris and crop residue and proper drainage minimize the disease incidence. Thick mulching with paddy straw or other organic waste reduces the frequency of weeding and other intercultural operations, thereby avoiding injury to the plants. Spraying of sixer or saaf (1.5 g/litre of water) at 60 and 90 days after planting is recommended as preventive measure against collar rot. Trichoderma spp. has been found very effective against collar rot.

3.4. Integrated pest management

3.4.1. Sweet potato weevil

Sweet potato weevil (*Cylas formicarius*) is the most important pest causing very severe damage to the crop (Photo 25). Adult weevil makes puncturing on vines and tubers. The grubs bore and feed by making tunnels. Even the slightly damaged tubers are unsuitable for consumption due to bitterness. Yield loss may go up to 100% in severe cases. On an average 20-55% tuber loss occurs. The following integrated pest management will be effective for the control

1. Dip the vine cuttings in fenthion or fenitrothion 0.05% solution for 10 minutes before planting.
2. Earthing up at two and three months after planting.
3. Install synthetic sex pheromone traps @ 1 trap/100 m^2 area to collect and kill the male weevils.
4. Destroy the infested crop residues after harvest by burning

Photo 25. Sweet potato weevil

4. Livestock technologies

4.1. Backyard poultry

Backyard poultry production has been established as best tool for poverty alleviation and also to generate cash income. It can be adopted by landless or any type of farmer with or without land holdings. It is commonly referred as rural poultry production. It is advised to start with 20-50 birds and then further expansion can be had subsequently.

4.1.1. Breed

Rainbow Rooster: It is a dual-purpose, low input, multicoloured chicken from India (Photo 26). It was bred by Indbro Research and Breeding Farms in South India as a part of a food programme. Rainbow Roosters are able to sustain free-range and backyard rearing conditions. Rainbow Roosters mateure between 4 and 6 months. Its mortality rate is low (<2.0%), when managed as a layer with commercial feeds. Rainbow Roosters will lay 160-180 eggs in 72 weeks (16 months). The layers start laying at 160 days (five months). At the end of lay the birds weigh about 3.0 kg. The average egg weight is 60 g. Rainbow Roosters will star laying at five months and lay continuously for 10 months. When managed as meat birds, the rainbow Roosters will attain the average weight of 2.0 kg in 8 weeks under commercial feeds. Under scavenging condition, the Rainbow Roosters growth rate is a bit slower with the bird attaining the weight of 1.3 kg in 9 weeks. The average meat production for rainbow Roosters is 3.0 kg for male and 2.2 kg for female.

Photo 26. Rainbow Rooster chicks

Sonali: It is one of the coloured bird for rural poultry farming (Photo 27). It is a crossbred of Fayoumi femal and RIR (Rhode Island Red) male. This bird is reared for both eggs and meat. These birds (10-20) can be reared under free range conditions for egg purpose where plenty of natural feed is available. In case of commercial commercial farming,


TRIBAL SUB PLAN


PREM AZAD PREMJI FOUNDATION
TRIBAL SUB PLAN


TRIBAL SUB PLAN


TRIBAL SUB PLAN
TRAINING PROGRAMME ON
CROP DIVERSIFICATION WITH TUBER CROPS


TRIBAL SUB PLAN
CROP DIVERSIFICATION WITH TUBER CROPS


TRIBAL SUB PLAN
TRAINING PROGRAMME ON
CROP DIVERSIFICATION WITH TUBER CROPS
VENUE: Benagudia, Kaliana(Block), Mayurbhanj(District)
ORGANISED BY


CROP DIVERSIFICATION
WITH TUBER CROPS


Training Program on


Training Program on
CROP DIVERSIFICATION
WITH TUBER CROPS


Tribal Sub-Plan
कम कमलों की उपज दिवस
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Tribal Sub-Plan


SWACHHTA PAKHWADA
KISAN DIVA


कंद फसल दिवस ଜନ୍ଦ ଫସଲ ଦିବସ
TUBER CROPS DAY
(18th January 2023)


Tribal Sub-Plan
कंद फसल दिवस ଜନ୍ଦ ଫସଲ ଦିବସ
TUBER CROPS DAY


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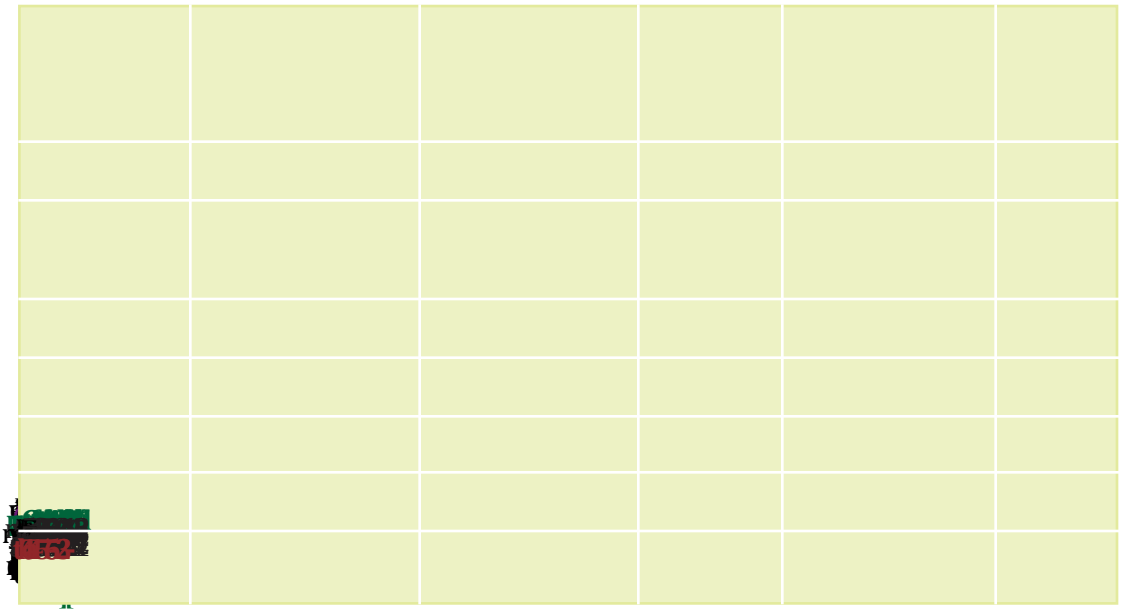

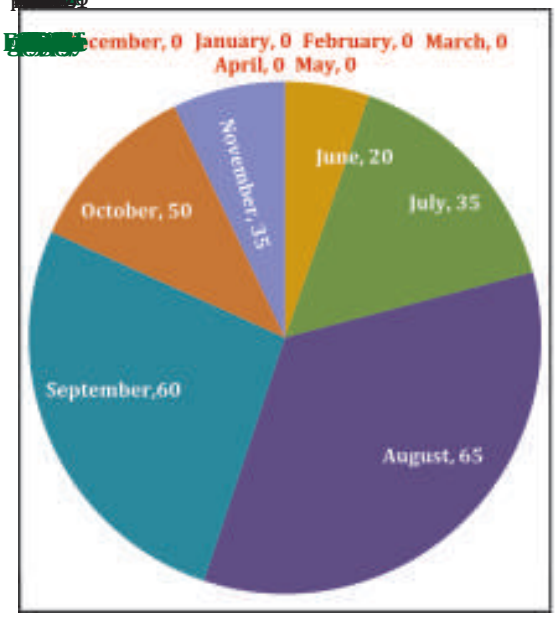
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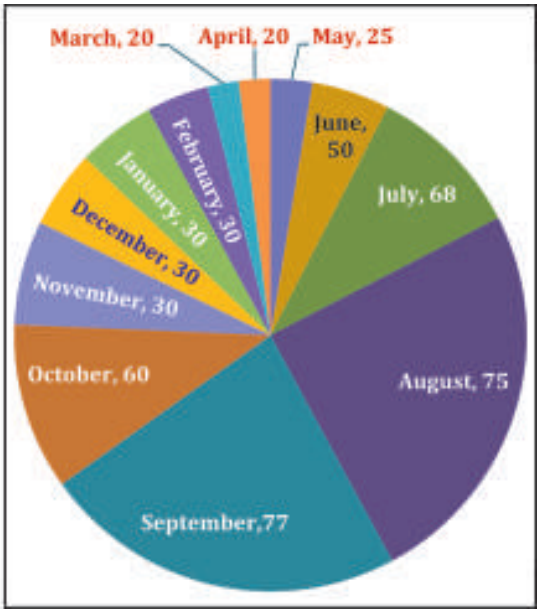
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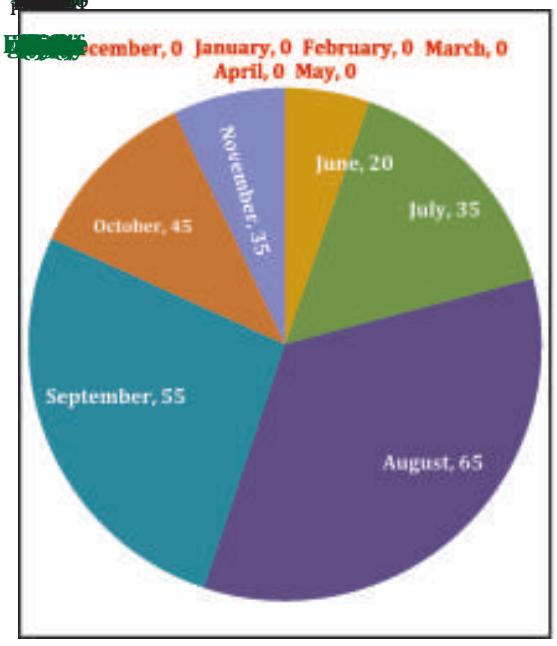
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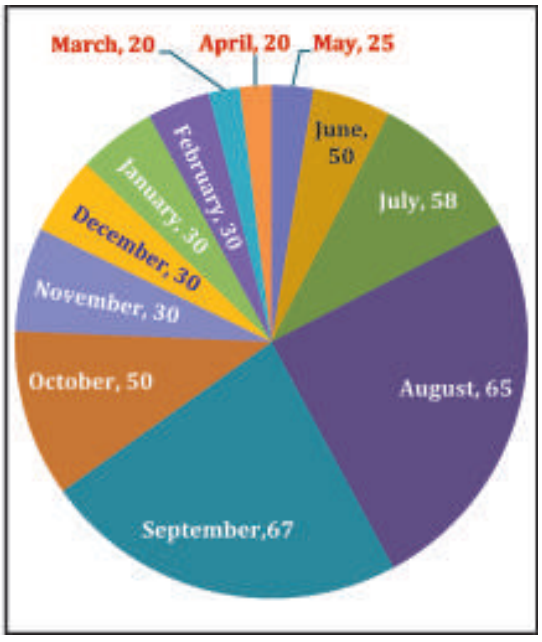
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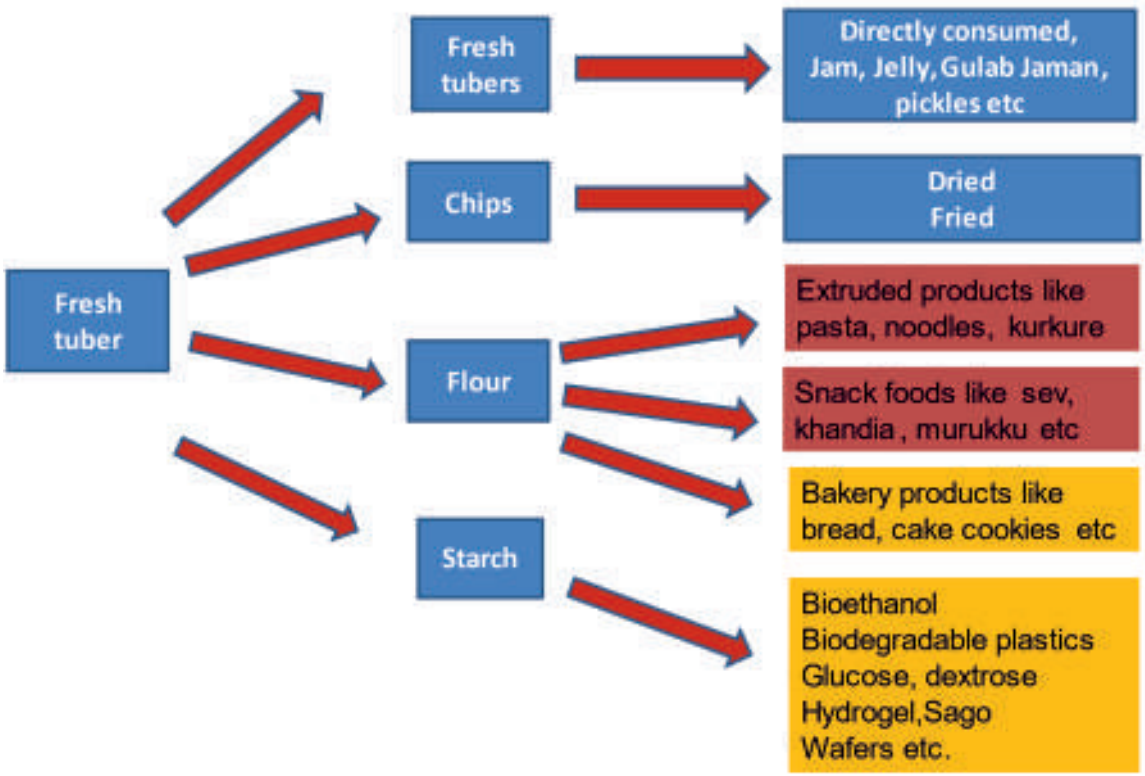
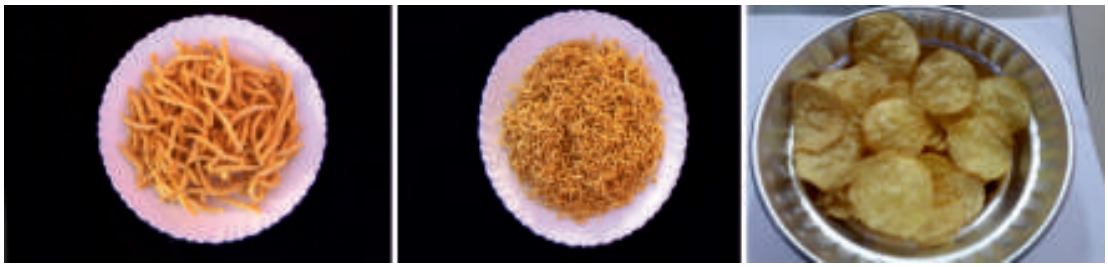
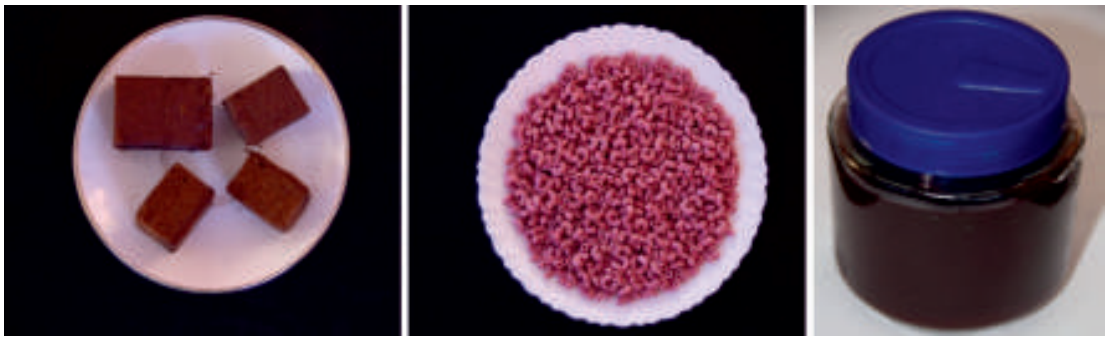

Fresh tuber
Fresh tubers
Chips
Flour
Starch
Directly consumed, Jam, Jelly, Gulab Jaman, pickles etc
Dried Fried
Extruded products like pasta, noodles, kurkure
Snack foods like sev, khandia , murukku etc
Bakery products like bread, cake cookies etc
Bioethanol
Biodegradable plastics
Glucose, dextrose
Hydrogel,Sago
Wafers etc.










YAMS

भाकृअनुप-केन्द्रीय कंद फसल अनुसंधान संस्थान
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SREE TELIA: A new short duration variety of taro for Odisha

M. Nedunchezhiyan, Kalidas Pati, V.B.S. Chauhan
K. Laxminarayana, R. S. Misra and M.N. Sheela

Taro (Colocasia esculenta (L.) Schott.), a carbohydrate rich tuber crop is popular in Odisha. Delicious cuisines are prepared from taro and it is a special item in 'Dalmeh', which is a favourite dish of Odisha. In Odisha, taro is cultivated under rainfed conditions during kharif. However, due to climate change and early cessation of monsoon, most of the taro crops suffer terminal moisture stress due to long duration. Hence, the Regional Centre of ICAR-CTCRI, Bhubaneswar has developed a new short duration variety i.e. Sree Telia which can be harvested within 120 days after planting. This variety can also be planted during summer with protective irrigation. Sree Telia produces 7-9 numbers of cormels per plant. This variety is having good cooking quality and low acridity (calcium oxalate 12.6 mg/100 g). The average yield is 10-12 t/ha.

Sree Telia : A) Field view B) Plant structure C) Mother corms D) Cormels

SREE HIRA: A new elite variety of taro for Odisha

M. Nedunchezhiyan, Kalidas Pati, V.B.S. Chauhan
K. Laxminarayana and M.N. Sheela

Taro (Colocasia esculenta (L.) Schott.) is one of the most important starchy tuber crops. Taro is known as Arvi in Hindi, Chembu in Malayalam, Chappan Kizangu in Tamil, Chemadu in Telugu, shama gadde in Kannada, Saru in Oriya, and Kachu in Assamese and Bengali. It is believed to have originated in South Central Asia, perhaps India or Malaysia. In edible type, cormels are mostly preferred as vegetables. Relatively large size cormels are arising from the side of mother corm. Cormels and corms are used as planting material.

The Sree Hira, a new elite taro variety is developed from the Regional Centre of ICAR-CTCRI, Bhubaneswar. It is suitable for rainfed upland and irrigated medium and low land under Odisha conditions. This variety is tolerant to leaf blight which is very prevalent in traditional varieties of Odisha. Sree Hira also produce 12-16 numbers of cormels with each measuring 14-16 cm length. This variety is also having good cooking quality and low acridity.

Sree Hira: A) Kharif crop field view B) Rabi crop field view C) Plant structure D) Cormels E) Cormels clump with corm F) Harvested cormels G) Mother corms


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