TRIBAL SUB PLAN
A Decade of Service to Tribals

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FOREWORD

(M.N. Sheela)
Director

Root and 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 root and tuber crops are sweet potato (*Ipomoea batatas*), greater yam (*Dioscorea alata*), cassava (*Manihot esculenta*), taro (*Colocasia esculenta*), elephant foot yam (*Amorphophallus paeoniifolius*), yam bean (*Pachyrhizus erosus*) and arrowroot (*Maranta arundinacea*) etc. During 2012-2021, the Regional Centre of ICAR-CTCRI, Bhubaneswar under the Tribal Sub-Plan (TSP), demonstrated tuber crops technologies in 1840 tribal farmers' fields. Under TSP, this Centre has distributed quality planting materials of greater yam tubers (69500 kg), elephant foot yam corms (34800 kg), colocasia/taro cormels (20000 kg), sweet potato vine cuttings (38.6 lakh nos.) and tubers (2080 kg), cassava stems (42800 nos.) and yam bean seeds (822.5 kg) at free of cost to the tribal farmers. Under this project, backyard poultry (6220 nos.), ducks (750 nos.), goats (109 nos.) and pigs (120 nos.) were also distributed to the tribal farmers for improving their livelihoods. Seeds of cereals (rice 260 kg and maize 70 kg), millets (ragi 26 kg), pulses (red gram 66 kg) and vegetable seeds (18.6 kg and seed kits 1085 nos.) were also distributed to include in their farming system to achieve food and nutritional security.

Dr. M. Nedunchezhiyan, Principal Scientist of the Centre successfully led the TSP project for a decade and other scientists supported him to spread tuber crops technologies in the Tribal areas of Odisha, Jharkhand and Chhattisgarh. This publication presents a compilation of work done under the TSP during the decade, 2012-2021. The out-put of the TSP project indicated that sufficient tubers, cereals, millets, pulses, vegetables, meat, eggs etc. were made available for household consumption as well as for selling 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 were enhanced in the project areas.

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.

(M.N. Sheela)
Director

PREFACE

(M. Nedunchezhiyan)
Principal Scientist

Tribals live in remote, inaccessible disadvantaged locations in eastern India. They contain their life with available resources in their vicinity. Tribal agriculture is traditional and they mostly cultivate cereals and millets. Though they have special niche for root and tubers they prefer to collect themfrom near by forest areas. Very few tribal farmers cultivate sweet potato and arrowroot. The Regional Centre of ICAR-CTCRI has developed nutritionally rich high yielding varieties of tuber crops which are suitable for tribal farming. Under 'Tribal Sub-Plan' (TSP), the Regional Centre has taken tuber crops technologies to tribal regions of Odisha, Jharkhand and Chhattisgarh to improve the livelihood of tribal farmers during 2012-2021. During this period, the Centre has given quality planting materials of tuber crops, improved varieties of cereals, pulses, vegetable seeds, poultry birds, ducks, goats etc. free of cost to the tribal farmers and demonstrated the improved technologies for higher yield and nutrition in their fields. Through TSP, 1840 tribal farmers were benefited. Tribal farmers were trained on scientific methodsof tuber crops cultivation through on campus and off campus 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', at the Regional Centre of ICAR-CTCRI, Bhubaneswar.

Scientists from ICAR-CTCRI, ICAR-IIHR (CHES), ICAR-CIFA, ICAR-IIWM, OUAT and officials of Directorate of Horticulture visited the tribal farmers' fields and imparted training. This project was ably supported by then directors of ICAR-CTCRI, Thiruvananthapuram Dr. S.K. Chakrabarti, Dr. James George,Dr.Archana Mukherjee and Dr. V. Ravi as well as the present director, Dr. M.N. Sheela.

NGOs PRAGATI and SOVA in Koraput, ORRISSA in Kandhamal, SACAL and Directorate of Horticulture in Gajapati in Odisha, Rama Krishna Mission Ashrama, Ranchi and Ramakrishna Mission, Deogarh in Jharkhand and Rama Krishna Mission, Narayanpur, Chhattisgarh also helped in this project for conducting tuber crops demonstrations and training programmes.

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

(M. Nedunchezhiyan)
Principal Scientist

TRIBAL SUB PLAN AT A GLANCE

The Tribal Sub Plan (TSP) scheme was introduced for rapid socio-economic development and protection of schedule tribes against exploitation through legal and administrative support. The basic objective of Tribal Sub Plan is to channelize the flow of funds and benefits from the general sectors in the Central Ministries/Departments for the development of Scheduled Tribes (ST) at least in proportion to their population, both in physical and financial terms.

The broad objectives of the TSP are:

- Substantial reduction in poverty and un-employment.
- Creation of productive assets in favour of Scheduled Tribes to sustain the growth likely to accrue through development efforts.
- Human resource development of the Scheduled Tribes by providing adequate educational and health services and
- Provision of physical and financial security against all types of exploitation and oppression.

The general guidelines for implementation of TSP schemes are:

- TSP funds are non-divertible and non-lapsable.
- Only those schemes should be included under TSP which ensures direct benefits to individuals or families belonging to ST.
- Priority should be given for providing basic minimum services like primary education, health, drinking water, nutrition, rural housing, rural electrification and rural link road.
- Expenditure in schemes may be incurred in ST concentrated areas i.e. in the villages, blocks and districts having more than 40% of population, largely benefiting the ST.
- Expenditure to be incurred to develop agriculture and allied activities like irrigation, animal husbandry, dairy development, vocational training etc. that provide a source of livelihood to the ST population.
- Wage component, especially under rural employment schemes, should not be included under TSP.
- Innovative projects that draw upon institutional finance to supplement plan allocations may be drawn up.

EXECUTIVE SUMMARY

The carbohydrate rich root and tuber crops are next to cereals and grain legumes in supplying energy to the world population. The vegetatively propagated root and tuber crops i.e. 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. have great flexibility in adjusting any farming system and also, they are the best climate resilient crops under changing climate. The Regional Centre of ICAR-CTCRI, Bhubaneswar and ICAR-CTCRI, Thiruvananthapuram have developed number of high yielding and nutritionally rich varieties and resource use efficiency technologies of tuber crops. The technologies are very well fit into crop diversification as well as farming systems. Under Tribal SubPlan (TSP), the Regional Centre of ICAR-CTCRI, Bhubaneswar has demonstrated tuber crops technologies in crop diversification as well as location specific farming systems in 1840 tribal farmers fields in Odisha, Jharkhand and Chhattisgarh states for a decade (2012-2021). Under TSP, the Regional Centre of ICAR-CTCRI, Bhubaneswar has distributed quality planting materials of greater yam tubers 69500 kg, elephant foot yam corms 34800 kg, colocasia/taro cormel 20000 kg, sweet potato vine cuttings 38.6 lakh and tubers 2080 kg, cassava stems 42800 nos. and yam bean seeds 822.5 kg at free of cost to the tribal farmers. Under this project, backyard poultry 6220 nos., ducks 750 nos., goats 109 nos. and pigs 120 nos. were also distributed to the tribal farmers for improving their livelihood. Seeds of cereals (rice 260 kg and maize 70 kg), millets (ragi 26 kg), pulses (red gram 66 kg) and vegetable seeds 18.6 kg and seed kits 1085) were also distributed to include in their farming system to achieve food and nutritional security. Tribal farmers their also contributed elite land race seeds of rice, ragi, maize, red gram, green gram and black gram for farming system demonstrations.

To reduce the drudgery of field operations, small agricultural implements were distributed to the tribal farmers. Sprayers 539, hand hoe 717, sickle 717, crow bar 717, pickaxe 717, cultivator 118, garden hoe 118 and spade 688 numbers were distributed to the tribal farmers. As the tribal farmers' fields are adjacent to the forest, to protect tuber crops from animals GI mesh fencing material 3370 kg were also distributed. Raised cement floor for goat keeping (57 Nos.) and duck-shed (55 Nos.) were also constructed near to their fields. Most of the tribal villages are remote, with less accessibility and without electricity

and hence, during 2016-17, a solar pump set was installed in Dayanidhiguda village, Koraput Block, Koraput District, Odisha and during 2017-18, one more solar pumpset was installed in Ranchi district, Jharkhand for irrigating the crops during dry spell and also to cultivate crops during rabi season.

Seventy-four trainings and exposure visits were organized to train 4068 tribal farmers (2505 men and 1563 women) on scientific methods of tuber crops, cereals, pulses and vegetable crops cultivation, backyard poultry, duckery, goatery piggery, mushroom and apiary farming. Crops and animals performance were monitored by the experts by regular field visits.

The results of the demonstrations indicated that tuber crops yield was influenced by the locations. The yield variation of greater yam was 22.3-26.2 t/ha, elephant foot yam 20.2-25.0 t/ha, colocasia/taro 14.3-15.8 t/ha, sweet potato 11.6-14.2 t/ha, yam bean 15.4-20.5 t/ha and cassava 15.4-18.3 t/ha. Tuber crops-based farming system (0.4 ha model) resulted in net return of Rs 120938/0.4 ha with crops and backyard poultry, and Rs 148375/0.4 ha with crops, backyard poultry and goats. The income of the tribal farmer is doubled with the inclusion of tuber crops in their cropping/farming system and they had sufficient food for household consumption. Thus, food and nutrition security and livelihood improvement are achieved through tuber crops technologies.

CONTENTS

1. INTRODUCTION

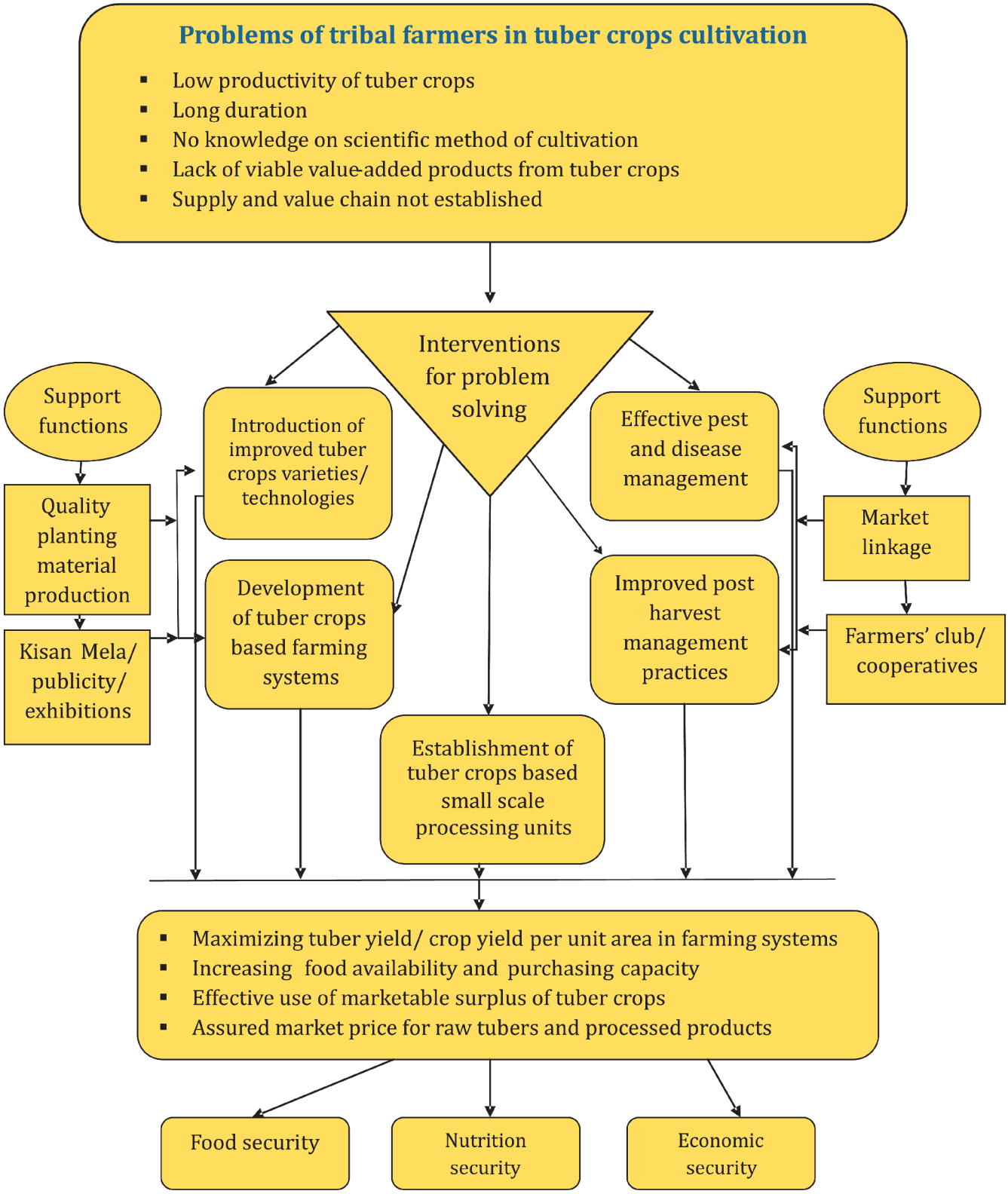
Tuber crops find special niche in tribal food habits. They play crucial role in food and nutritional security of the tribals. Sweet potato is the predominant tuber crop in tribal dominated Odisha (>40,000 ha), Chhattisgarh (>10,000 ha) and Jharkhand (>10,000 ha). Yams, taro, elephant foot yam, arrowroot, yam bean etc. are mostly grown in backyards and sometimes collected from forest. The yield of tuber crops in the present production systems is very low. But the productivity of tuber crops is as high as 50 t/ha. Tuber crops are able to grow in different agro-climatic conditions and fit very well with different cropping systems and homestead gardens for year-round production. Systematic effort was undertaken to improve the efficiency of these production systems by integrating them with 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. A number of bioactive constituents such as phenolic compounds, saponins, bioactive proteins, glycoalkaloids, and phytic acids are rich in various tuber crops. The Regional Centre of ICAR-CTCRI, Bhubaneswar has released vitamin A rich sweet potato variety Bhu Sona (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' focussed more on outreach programmes complemented with need-based research modules, seed materials development and distribution, knowledge dissemination, production and processing linkage, capacity building and entrepreneurship building.

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

1.2. Conceptual framework



2. PROJECT LOCATIONS

2.1. Background information about Odisha

Odisha is an eastern state of India comprising hills and plateau, and coastal plain regions (Photo 1). Odisha has a geographical area of 155707 km^2 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 range from fertile alluvial deltaic soils in coastal plains, mixed red and black soils in central table land, 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 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.

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.

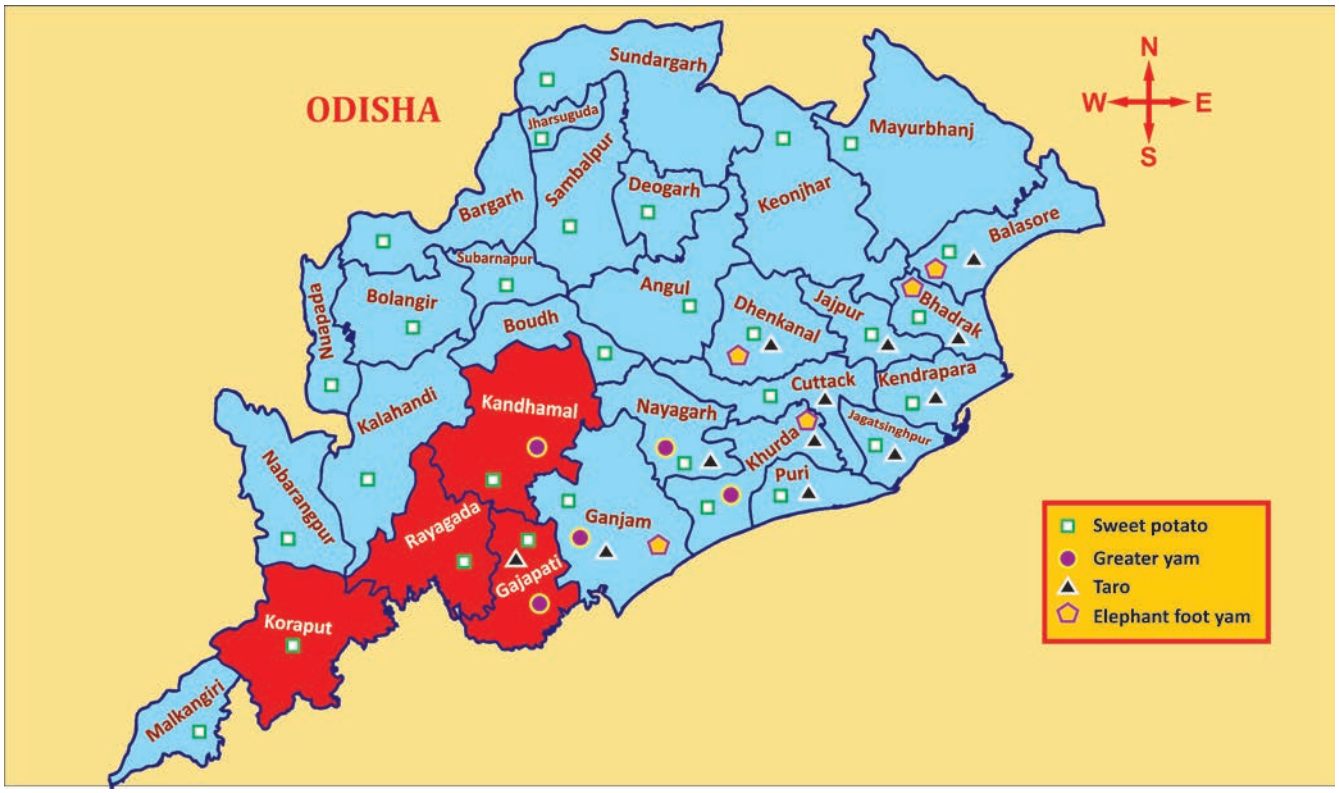


Photo 1. Odisha

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, goatery etc. as integrated farming system in tribal areas of Koraput, Rayagada, Kandhamal and Gajapati districts of Odisha.

2.2. Background information about Jharkhand

Jharkhand state which came into existence during the year 2000 is predominated by tribal population on eastern extremity of Indian plateau, located between 21^0 to 24^0 N latitudes and 84^0 to 87^0 longitudes with elevation ranging from 450 m to 1000 m above mean sea level (Photo 2). Jharkhand has a geographical area of 79.71 lakh ha with 24 districts. The state has been endowed with varying climatic conditions suitable for growing large number of horticultural crops. Entire Jharkhand on the basis of the climatic parameters can be termed as semi-humid subtropics. The state receives rains round the year; however, its concentration is more during the span of June to September. The crops planted during rainy months may not need additional irrigation. However, the period from November to May are rain deficit months, where irrigation would be essential and amount of irrigation required will depend upon the crop species and evaporative demand of the atmosphere.

Broadly soil of the Jharkhand is associated with ten soil association groups of which red-yellow-light grey catenary soil and yellow medium deep light textured catenary soil groups have frequent

occurrence. Red-yellow-light grey catenary soil occupies major portions of the districts of Santhal Parganas, Hazaribagh, Dhanbad, Ranchi and Singhbhum. The soil on slopes and upland are well drained, red coloured, light textured, strongly to moderately acidic in reaction and are shallow to medium deep over rocks and murrum (partly weathered material). The fertility status of these soils is poor which is low in nitrogen and phosphorus and medium in potash content.

The soils of medium uplands are moderately yellow coloured, acidic in reaction and light to medium in texture. These soils are drained and less acidic compared to the soils of slopes. The soils of lower land valley are poorly drained and have grey colour. It is neutral to slightly alkaline in reaction and fairly deep. The soils are generally more fertile than the upland ones. Yellow-reddish and yellow medium deep textured catenary soils are found in the hilly parts of Palamu, western part of Hazaribagh and Ranchi districts. These soils resemble the yellow soils of the above-mentioned broad soil association group in most of their characteristics except thick murrum beds which are found below 75-150 cm.

In Jharkhand, tuber crops are cultivated in all the districts. Sweet potato, elephant foot yam and *colocasia* are commonly cultivated both in tribal as well as non-tribal areas. Socio-economic

Photo 2. Jharkhand

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, duckery, goatery, piggery etc. as integrated farming system in tribal areas of Deogarh and Ranchi districts of Jharkhand.

2.3. Background information about Chhattisgarh

Chhattisgarh is situated at central part of India and location is 17^0 - 24^0 N and 80^0 .40' - 83^0.38' E (Photo 3).Chhattisgarh is the 10th largest state in India, with an area of 135,190 km^2. By population, it ranks as the 16^{th} most-populated state of the nation. It is an important electricity, coal and steel-producing state of India. Chhattisgarh accounts for 15% of the total steel produced in the country. Chhattisgarh is constituted with 27 districts.The Chhattisgarh state is agro-climatically divided into three zones *viz.*Bastar plateau, Chhattisgarh plain and Northern Hills.

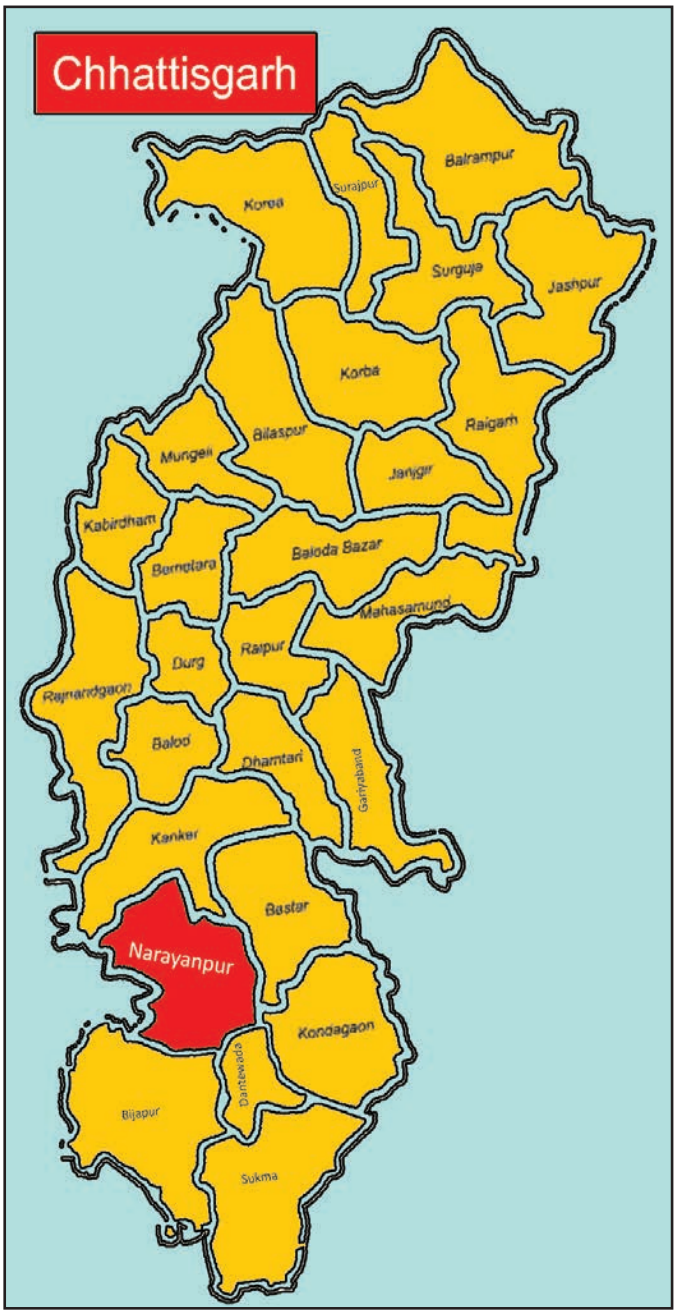


Photo 3. Chhattisgarh

Various types of soils are found throughout the state. Two types predominate: the black, clayey soils and the red-to-yellow soils. The latter are less fertile and contain substantial amounts of sand. The climate in Chhattisgarh is governed by a monsoon weather pattern. The distinct seasons are summer (March to May), winter (November to February), and the intervening rainy months of the South-West monsoon (June to September). The summer is hot, dry, and windy, with high temperatures typically reaching 30^0 C in all parts of the state; in some areas temperatures regularly rise above 30^0 C. Winters are usually pleasant and dry, with temperatures around 20^0 C. In December and January there is considerable rainfall over the northern part of the state, although the state as a whole receives most of its precipitation during the South-West monsoon. Rainfall usually ranges from 47 to 60 inches (1200 to 1500 mm) annually.

The total area of tuber crops in Chhattisgarh is 2391 ha with a total production of 64880 t.The average productivity of all the tuber crops is 22.7 t/ha. The above data were recorded through conventional survey from all 27 districts of Chhattisgarh during the year 2013-14. Raipur is the district with maximum elephant foot yam area (61.0 ha) and production (3440 t) followed by Mahasamund and Raigarh districts. Bastar district is having the maximum area and production of cassava (25.1 ha and 882 t), *Colocasia*/arvi in *kharif* season (77.1 ha and 2272 t), greater yam (27 ha and 868 t), sweet potato (39.4 ha and 1103 t), arial yam (10.1 ha and 264 t) and kewkand (10.1 ha and 315 t). In Kanwardha district, the area of summer *Colocasia* is 303.5 ha and production are 5858 t under irrigated condition followed by Bastar and Jaspur. Summer *Colocasia* in Kawardha district is mostly concentrated in the river banks of *Sankri* river. Surajpur district is the largest producer of bunda (1608 t) in 47 ha area followed by Surguja and Balrampur during *kharif* season. Surguja is the district with maximum summer irrigated bunda area (12.9 ha) and production (440 t). Bijapur district having maximum area and production of *Curcuma angustifolia* (11 ha and 285 t) followed by Dhamtari (10.9 ha and 224 t) and Kondagaon (8.8 ha and 224 ha). Kanker is the district with maximum other minor tuber crops area (6.6 ha) and production (79 t) followed by Rajnandgaon (4.4 ha) and Dhamtari (3.60 ha). Dugukondal block of Kanker and Bhairamgarh block of Rajnandgaon districts were identified as special pockets for major growing area of *Dioscorea esculanta* during survey, Bastar division and Surguja for *Curcuma angustifolia and Dioscorea floribunda*, Nagari block of Dhamtari district for *Dioscorea hispida,* Pakhanjur block of Kanker for swamp taro; Bastar-Narayanpur-Sukma-Damtewada districts for *Dioscorea pentaphylla, Dioscorea spicata* and *Dioscorea rotundata.*

The Regional Centre of ICAR-Central Tuber Crops Research Institute, Bhubaneswar under Tribal Sub Plan has conducted demonstrations on tuber crops technologies as crop diversification in tribal areas of Abujmarh, Narayanpur district, Chhattisgarh.

3. DEMONSTRATIONS CONDUCTED ON TUBER CROPS TECHNOLOGIES

Tuber crops technologies such as high yielding and biofortied varieties of sweet potato, greater yam, elephant foot yam, taro, yam bean and cassava as well as resource use efficient production systems, integrated disease management and integrated pest management were selected for conducting demonstrations. Further livestock technologies such as backyard poultry, duck rearing, goat rearing and piggery were also selected to include in demonstrations for augmenting farmers income.

3.1. Demonstrations conducted on high yielding and biofortified varieties

3.1.1. Sweet potato

Variety

Bhu Sona: Spreading, medium duration (110 days) orange fleshed variety, rich in β-carotene (14 mg/100 g fresh tuber weight) (Photo 4). Tuber yield is 20-25 t/ha.

Photo 4. Bhu Sona variety

Bhu Krishna: High yielding, medium duration (110 days) and high anthocyanin (95 mg/100 g fresh tuber weight) variety with good cooking quality (Photo 5). Tuber yield is 22-25 t/ha.

Kishan: Spreading, medium duration (110-120 days) variety. High sugar and dry matter content variety. Tuber yield is17 t/ha.

Photo 5. Bhu Krishna variety

Gouri: Semi-spreading, medium duration (110-120 days) variety. Tuber skin colour is red and flesh colour is orange. Tubers are rich in β-carotene (4.5-5.5 mg/100 g of fresh tuber weight). Tuber yield is 19 t/ha.

Kalinga: Spreading, medium duration (105-110 days) variety. Purple red skinned tuber with creamy flesh, Suitable for rainfed and irrigated uplands. Dual-purpose variety can be used for food, animal feed and for starch extraction. Tuber yield is17.2 t/ha.

Sankar: Semi-spreading medium duration (120 days) variety. Tuber skin is red and flesh is white in colour. Good cooking quality. Tuber yield is13.7 t/ha.

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 for 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 required 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 is carried out 30 days after planting followed by earthing up which 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 (*Cylas formicarius*) is the most important pest causing very severe damage to the crop. Adult weevil makes punctures 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 planting 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 6). Tuber cooking quality is soft, non-sticky and excellent. Shelf-life of the tuber is 6-7 months. Tuber yield is 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 7). Tuber cooking quality is soft, non-sticky and excellent. Self-life of the tuber is 4-5 months. Tuber yield is 30-35 t/ha.

Sree Neelima: It is a long duration (9-10 months) variety twining right-side. A high yielding variety with purple flesh colour, good culinary and nutritive quality. It has anthocyanin 15-50 mg/100 g on fresh weight basis (Photo 8). 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 is 35 t/ha.

Photo 6. Orissa Elite variety

Photo 7. Sree Nidhi variety

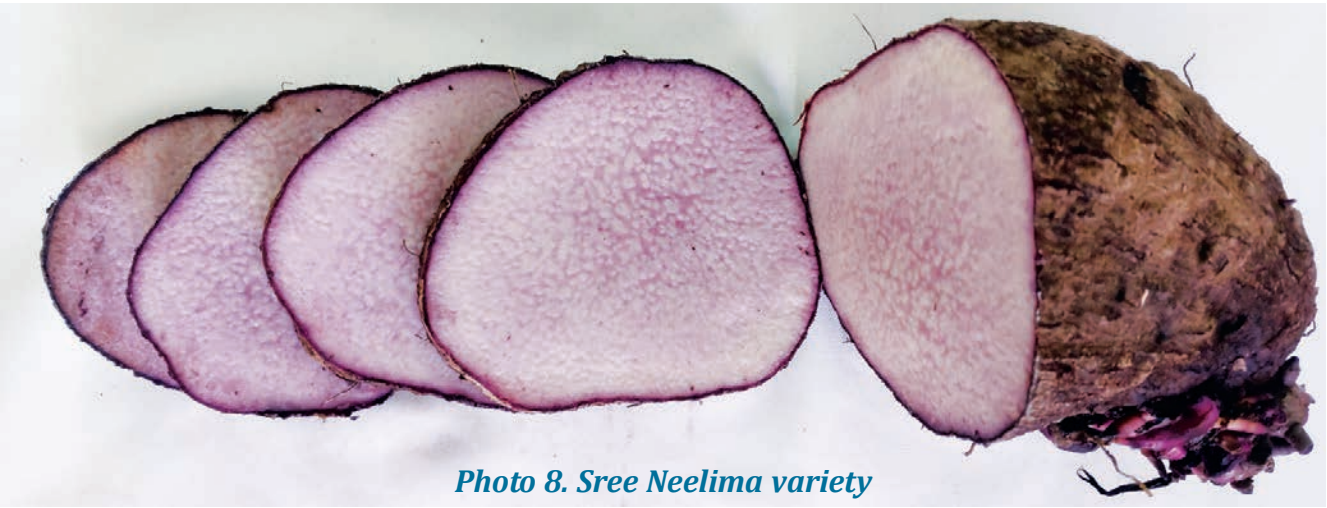


Photo 8. Sree Neelima variety

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 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 eastern 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 and encourages 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 climb on any available support. In the absence of available support, the yam vines would simply lie on the ground. Failure to stake yams was reported to cause drastic yield reduction. Bamboo or wooden twigs staking is recommended. Individual staking, pyramidal staking and trellising are different methods of staking which are 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 in 180-210 days after planting. It is suitable for both *kharif* and *rabi* season. The variety produces smooth corms, free from daughter corms (Photo 9). The cooking quality is very good low acridity (calcium oxalate 0.03 mg/100 g fresh tuber). It contains β-carotene 2412 IU. Tuber yield is 42 t/ha.

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 incorporated with organic matter or compost to make the soil friable and light. Water-logging is harmful at any stage of crop growth.

Photo 9. Gajendra variety

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 at a spacing of 90 cm x 90 cm is recommended. Corm setts can be planted either in 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 ICAR-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 10). The variety is tolerant to leaf blight and dasheen mosaic virus. Cormels are having excellent cooking quality and non-acrid. Cormel yield is 20 t/ha.

Photo 10. Muktakeshi variety

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 11). Cormels are having good cooking quality. Cormel yield is 15-18 t/ha.

Photo 11. Telia 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 planting is suitable 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 12). Crop grown for tuber purposes are mostly free from pest infestation. Tuber yield is 35 t/ha.

Photo 12. 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

Depending upon location, the sowing time varied from June to September.

Spacing and method of sowing

Sowing on ridges at a spacing of 60x20 cm gives good yield. Yam bean is sown 1-2 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: It is erect branching early maturing variety with good cooking quality (Photo 13). 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 14). 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.

Sree Visakham: It is long duration variety with branching type. The variety is dual purpose. The crop duration is 10-11 months and yielding 35-38 t/ha.

Vellayani Hraswa: It is a short duration variety and branching type. Tubers having good cooking quality. The crop duration is 210 days and yielding 24-26 t/ha.

Photo 13. Sree Jaya variety

Photo 14. 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 geminivirus. 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. Demonstrations conducted on resource use efficient production systems

3.2.1. Greater yam+maize intercropping system

Maize was found suitable intercrop in greater yam cultivation (Photo 15). Greater yam is planted at 90 cm x 90 cm spacing in ridge and furrow system. In the intra-rows, between two greater yam plants, three maize plants are sown. Thus, maintaining spacing of 90 cm x 30 cm for maize. Both greater yam and maize are to be planted /sown at the same time. Immediately after planting/sowing mulching with 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 Kand the 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.

Photo 15. Greater yam+maize intercropping system

3.2.2. Sweet potato+red gram intercropping system

Sweet potato+red gram (3:3 rows) (1.8 m strip of each component crop) strip intercropping system was demonstrated to the farmers (Photo 16). In this system, 3 rows of sweet potato were planted on the ridges raised 60 cm apart. Plant to plant spacing 20 cm was followed. Red gram was sown in three rows with row to row spacing of 60 cm. Plant to plant 20 cm spacing was followed. The recommended dose of fertilizer N-P-K 50-25-50 kg/ha was applied to sweet potato and N-P-K 20-40-20 kg/ha was applied to red gram. In this system, sweet potato and red gram occupies 50% area each. Hence, half of the recommended dose of fertilizers of sweet potato and red gram was applied. This system enriched the soil with organic matter and nitrogen due to presence of red gram crop. This system also conserves soil moisture and reduce soil erosion. This system also reduces sweet potato weevil infestation and fertilizer requirements.

Photo 16. Sweet potato+red gram intercropping

3.3. Demonstrations conducted on integrated disease management (IDM)

3.3.1. 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 17). The entire leaf area is destroyed within few days. Under cloudy weather conditions with intermittent rains and temperature around 28°C, 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 are tolerant to leaf blight have been reported from India. The cultivar Muktakeshi has shown 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,

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*.

Photo 17. Taro leaf blight

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. 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 18).

Photo 18. 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. Demonstrations conducted on integrated pest management (IPM)

3.1.1. 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 (Photo 19). 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 19. Sweet potato weevil

4. DEMONSTRATIONS CONDUCTED ON LIVESTOCK TECHNOLOGIES

4.1. Backyard poultry

Backyard poultry production has been established as a best enterprise 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 made subsequently.

Breed

Vanaraja

It is one of the coloured bird for rural poultry farming (Photo 20). 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 farming, these birds can be reared under intensive/semi-intensive conditions by providing all necessary inputs just like commercial boilers. Backyard poultry breed with an egg production of 150-200 and 1.3 to 1.5 kg body weight at 10 to 14 weeks of age is viable rural village conditions.

Photo 20. Vanaraja breed

Kalinga Brown

It is a dual-purpose poultry breed. Kalinga Brown male and female attain average 2.6 and 1.6 kg body weight at the age of 180 days. The average monthly egg production is 24 nos. It is highly suitable to hilly region.

Open range

This is most common form of backyard poultry production. Here, the birds thrive on kitchen waste and others by grazing in the surrounding area. It can be integrated with *in-situ* azolla production to be served as feed supplement. Azolla contains 22-23% crude protein on dry weight basis and liked by grazing birds. It is rich in essential amino acids, vitamins, growth promoter intermediaries, minerals like calcium, phosphorus and carotenoids including beta carotene. It increases the growth rate of the birds to about 40%.

The birds are housed in low-cost houses made of mud, wire mesh with asbestos roofs costing about Rs 500-1000. Generally, farmers do not practice vaccination but it is advisable to have vaccination for Meacks disease, ranikhet disease and infections bursal disease. Other precautionary measures to be taken on observation are control of lice and tick infestation in adult birds and regular de-worming etc. Since it is self-sustaining system, brooding was done by birds and new chick production will continue. Males after attaining weight over one kg are disposed off leaving the male female ratio as 1:5 in the flock.

The most important fact in this venture is selection of germplasm. Birds which are able to save itself from predators (can fly/ run), able to attain one kg body weight by tender meat stage (12-16 weeks) or produce 150 or more eggs under this rearing/ feeding system are preferred.

Medication to open system

Generally, in poultry medication is done through drinking water. But the rural poultry (except intensive) fulfil its water requirement from outside the shelter; medication of bird through drinking water is not practicable. There are 2 other ways to medicate them.

1. Keep the birds thirsty for 3-4 h and do not allow them to come out of the shelter. Then at the entrance gate of shelter put the waterers (one waterer for 5 birds) and dissolve the medicine to be given at the recommended rate per bird in 40-50 ml water. The birds will come out from the shelter and drink the water. This will take care of the required dose of medicine. However, sometimes the medication is uneven and hence becomes less effective.

2. The second and more effective method is to calculate the quantity of medicine on the basis of number of birds and age group. Dissolve the medicine in the quantity of vitamin B-complex (0.5 ml/bird) and 0.5 ml/bird clean drinking water. Prepare a solution/ paste of it. On the day of medication one person can sit on the door of shelter catch the bird one by one and open its mouth while the second person using a simple dropper will put 5-6 drop of this medicine solution in the mouth of the bird and then release the bird for grazing. The method has been found best for even and effective medication. The same can also be used for the control of tick and lice.

Sanitation and hygiene

Weekly or fortnightly lime may be used in the shelter to destroy microbes and to prevent infection. The floor must be kept dry in all the season. Sick birds if any must be kept separately and medicated as above. In fast growing birds, vitamin B-complex must be given around 4-5 weeks and there-after at fortnightly interval for supplementation.

4.2. Duck rearing

The ducks (*Anas platyrhynchos*) which constitute nearly 4 to 5% of the total domesticated poultry of India are endowed with equal or better in production abilities compared to chickens. In our country, in many ways, duck production emerges as a better alternate to chicken production which can contribute substantially to food, income, employment and livelihood security of the masses. However, duck production in India, is still in unorganized form which is carried out in limited scale. Marshy lands and adverse climatic conditions of coastal areas which are not suitable for chicken production and animal husbandry, as a whole, can be effectively utilized for duck production. Ducks usually grow well with locally-available feedstuff and less manpower are needed to raise them using meagerly-equipped facilities. In rural areas, the women folk (including elderly women) and aged people (in age group of 50 to 70 too) can easily be persuaded to manage production of ducks.

Breed

Khaki Campbell

It is a British breed and mostly khaki coloured with a darker head usually olive green lacking the white ring of its Mallard ancestors (Photo 21). The Khaki Campbell duck has a modest plumage of khaki covering the entirety of the body. The egg production of the Campbell breed can be exceeding even the most efficient of egg-laying domestic chickens with the breed laying an average of 300 eggs a year. Campbell becomes mature at approximately 7 months.

Photo 21. Khaki Campbell breed

Backyard Rearing System

This backyard duck husbandry system is primarily meant for small and rural farmers. Here, the ducks get mingled with chickens and other avian species, throughout the area. They are mainly confined to the farm premises but may roam around the village. Under this, duck needs little care and small supplementary feedings, where they are usually kept enclosed near to farmer's house, at night. Flock-size under this system could range from 5 to 20 ducks. While, during day-time, the ducks are free to roam outside in search of feed, they are brought inside at night, by putting some extra feed in the night-shelters and nests (usually of earthen pots or wooded partitions) for laying eggs. An advantage of this system is that ducks go out to harvest their feed themselves. Although the performance under this backyard-system is generally lower than that of intensive systems, its hallmark of low or no-cost feed can compensate the disadvantage of lower performances.

Along with laying ducks, the table ducks (ducks for meat) can be reared in the rice fields post-harvest. Generally, farmers purchase ducklings from the hatcheries, 3 to 4 weeks before the rice harvest. The ducks usually selected for this system are of native meat type, local meat type and or

crossbred local x exotic varieties. After 3 weeks of age when the ducklings can consume whole rice grains, they are permitted to enter the newly harvested rice fields. Here, they forage the whole day on leftover or fallen rice grains, insects, shellfishes, small-frog, fish, and water plants. In the late afternoon, they can be moved back to pens or sheds near the household until next morning. The ducks raised in this system are usually finished at 2.5-3 months of age, when they achieve live weights of 1.6-2.0kg, especially for crossbred varieties. Now-a-days, since mainly high yielding varieties of rice are planted and harvested within a short period, only a limited time can be available for the duck-flocks to scavenge. As the result, this traditional system of post-harvest duck rearing has limited feasibility and is less in vogue.

4.3. Goat rearing

Goat farming is a profitable enterprise. Goat rearing is done by people since the time immemorial. Generally, goat farming means rearing goats for the purpose of harvesting milk, meat and fiber. Goats are called the "foster mother of human", because their milk is considered as the best milk for human consumption. Goat milk is low cost, nutritious, wholesome and easily digestible. All aged people from child to old one can easily digest goat's milk. Goat milk also has lesser allergic problems and used as an ayurvedic medicine for the people who are ailing with diabetes, asthma, cough etc. Goats are mainly grown for meat purpose. Goat meat is very tasty, nutritious and healthy. The goat's manure is a high quality natural fertilizer in crop field. This will directly help to maximize crop production. At present, goat farming has become a profitable and it requires a very low investment because of its multi-functional utility.

Goats have been considered as poor man's cow (mini cow) because of its immense contribution in rural economy and national income. Goats are small sized animal and can easily maintained and cared by women and children. For successful goat farming, you need to do some common tasks such as feeding, milking and caring. These simple tasks do not require much equipment, capital, labour or hard work. Goats don't require huge area for housing. Goats are good breeders and they reach sexual maturity within their 7-12 months of age and give birth of kids within a short time. Some goat breed produces numerous(4-5) kids per kidding. Risks are less for goat farming (even in drought prone areas) than any other livestock farming enterprise. Both male and female goats have almost equal value/price in the market, and no religious taboo against goat farming and meat consumption. Diseases are less in goats and they are capable of adopting themselves with almost all types of agro-climatic conditions. They can tolerate high and low temperature throughout the world.

Breed

There are different types of goat breeds available in India. Black Bengal goat is world famous. Local breed like Ganjam breed is famous in Odisha.

Black Bengal

The Black Bengal goat is a breed of goat found throughout West Bengal, Assam and Odisha. This breed is usually coloured black but it is also found in brown, white or grey (Photo 22). The Black Bengal goat is small in size but its body structure is tight. Its horns are small and legs are short. This goat breed is very suitable for meat, milk and skin production.

Photo 22. Black Bengal breed

Housing

Housing is an important factor for profitable goat farming. Small scale farmer generally keeps their goats with their other livestock animals. But for commercial production, a good quality goat housing system is highly recommended for better production. A good house not only give shelter and protects the goats from predators but also prevent them from various types ofgoat diseases. Always keep the house neat, clean and dry. Make proper ventilation and drainage system inside the house. Also ensure the availability of sufficient fresh air and light inside the house. Housing and goat farm design are of various types according to the production type and breed.

Feeding

Goats are herbivores animal. Usually goats prefer to eat grasses, plants, shrubs, weeds and herbs. Besides those feeds, goats also need energy, protein, vitamins, fiber and water for proper growth.

Care and management

Never feed goats with contaminated food or polluted water. Keep goat house neat and clean as much as possible. And clean their house on a regular basis. Vaccinate them timely, for keeping them free from all types of diseases and health problems.

Vaccination

Various types of viral diseases like PPR, goat pox, foot and mouth diseases and bacterial diseases like anthrax, brucelosis etc. are very harmful for goats. So, proper vaccination is a must to prevent the above diseases. The goats which were not vaccinated for PPR, goat pox, brucellosis vaccines previously, vaccinate them at the fifth month of gestation period. Vaccinate the kids PPR vaccine when they reach 5 months of age. Always take good care of the animals and vaccinate them timely to prevent unwanted health hazard and diseases. The chart gives the vaccination schedule (Table 1).

Total expenditure and profit

Total expenditure and profit from goat farming depends on the farming system, location, breeds, feeding cost and other factors. By good planing and proper management goat farming can be made more profitable. Small scale farming requires less investment with more profit.

Goat farming is a traditional, profitable, risk-less and very easy enterprise because of its multi utility and fast-growing rate. Goat rearing can help in poverty reduction and contribute for the economic growth of a country. Proper care and good management can ensure better production and high profit.

Table 1. Type and dose of vaccination

Vaccine name	Applying rate	Applying method
PPR	1 ml	Injection Under Skin
Foot & Mouth Disease	2 ml	Injection Under Skin
Anthrax	1 ml	Injection Under Skin

4.4. Piggery

Pig farming is a lucrative enterprise. Pig is grown for its meat 'pork'. To make a perfect pig farm everybody needs to follow some methods, which are described below.

Breed

Jharsuk

It is a crossbred pig variety developed by AICRPTC on Pig, Birsa Agricultural University, Ranchi. It has superiority in various economic traits over desi pigs. It was developed by crossing Tamworth, a British pig and local one having 50% inheritance of both, thereafter inter-se-mating and by continuous selection for several generations on the basis of black colour, faster growth and better reproductive

performances(Photo 23). The variety can gain approximately 80 kg body weight at slaughter age of 8-10 months. It can produce 8-12 piglets in each farrowing with two farrowing each year.

Photo 23. Jharsuk breed

On pasture

Firstly, it is very necessary to have a large area with a lot of grass and soil. Then it also needs a large fence so that the pigs can roam too far off easily and can feel comfort. But the farmers should always conscious about the structure of the fence. Farmers should use very strong wood and thick corner poles because the adult pigs become very strong and they can try to destroy the fence. As pigs are notorious diggers, farmers should dig deeply into the ground for poles. Thus, farmers can farm pigs on the pasture.

On a barn or hut

Pig farming in a barn is generally easy. Farmers should use concrete to make a barn for pig farming. It is very necessary to keep the pigs inside the farm. Farmers should make the floor slope so that the water can be used to clean the barn easily. Farmers should separate the feeding area to the

rest area for cleaning it easily. At least 10 feet deep and 10 feet wide area is perfect for every two pigs. The rest area should be half the size of the feeding area with a pool where they can bath and the pool should be at least 5 feet.

One should take-care the pigs in the barn in the following ways:

- Depending on number of pigs farmers should clean pens naturally twice in a week.
- It is very important to keep feeder full.
- Mud hole filled with water in outside pen.
- A lot of bedding is necessary in corner but not entire pen.

Feeding

Pig should be fed 18% crude protein. Farmers should not feed pig with table scraps and garbage. For better farming, the pig should be fed with lettuce and other vegetables, but meat products are not appropriate. If the farmers give meat products the pig will put on too much fat and it will decrease the profit. Pig should feed 10-15 pounds of feed a day when it will 130 pounds heavier. To make a pig in a perfect weight, farmers should feed ½ cup of corn oil 2 times each day mixed with 1 egg 2 times each day and ½ cup of milk re-placer powder twice a day,1 table spoon corn oil is also necessary. Proper and sufficient feeding brings success in pig farming.

Housing

Proper environment situation is very important for farming pig successfully. To farm pig farmers should make a pollution free environment. Without careful management of waste products, it may be very dangerous problem for child pig. It is a great and profitable process to make manure from the disposal of the pigs. It is very useful for agriculture. The environment of the outside and inside should protect all times because it is very essential to farming pigs. Inside environment is important for their health. The farming area should be made clean and dry. During the cold months, a heat lamp must be put and kept out of the north wind and south winds. Farmers should use straw as bedding during the winter. During summer season, it is very much required that the pig has a place to lay in mud in the pen. If the pigs sweat or stay in a dry environment pigs will lose 5-10 pounds a day. So, always farmers should beconscious about the pig's health and always try not to sweat them. To sell pigs commercially the pigs should reach at least 220-295 pounds of weight.

Health and diseases

- Farmers should beconscious about pigs' health. So, medical attention is essential.
- Farmers should be aware about the symptoms of diseases, like change in eating behaviour, diarrhea, eye discharge, excessive coughing, hernia, dry skin and irregular spots on skin, excessively long hair, back bone showing etc.

- If the pig has diarrhea, farmers should call veterinarian and treat it carefully. Without proper treat pigs can be dehydrated and lost its weights quickly. This situation can also lead to death.
- If the pigs are coughing it is very essential to contact with veterinarian as soon as possible.
- Pigs should not give antibiotics 21-45 days before slaughter date.
- Pigs must be wormed with safe guard swine wormier or Algard monthly to kill whip.

Pig farming is very attractive and profitable enterprise. For successful pig farming, farmer needs training. For effective pig farming farmers should make perfect shelter for pigs. They should give proper food and proper medical protection. Without rearing pigs properly, it is not possible to earn a large sum of money. So, to earn money farmers should always careful about their pigs.

5. METHODOLOGY ADOPTED

The implementation of various models of the thematic interventions was done by adopting a participatory approach with the farmers. For this purpose, initially, village level committee was constituted in collaboration with the villagers and farmers were motivated to become beneficiaries of the project. The targeted beneficiaries were tribal small and marginal farmers. Thereafter the interventions were prioritized based on the interest and willingness of the selected households. Livelihood profile of the farmers, their interests and the potentials with him were documented.

The aim of the Tribal Sub Plan project is to create sustainable livelihood for tribal farmers of eastern India, taking a holistic participatory approach with an aim to double farmes income. To achieve this aim, resource generation, expansion and entrepreneurship with backward and forward linkages in integrated manner were envisaged. Implementation of an innovative technical approach was the theme of the project.

6. INPUTS DISTRIBUTED

6.1. Planting/seed materials

Under Tribal Sub Plan (TSP), quality planting materials of tuber crops were given free of cost to the beneficiaries. During 2012-22, the quality planting materials of elephant foot yam tubers 34800 kg, greater yam tubers 69500 kg, taro tubers 20000 kg, sweet potato tubers 2080 kg, yam bean seeds 822.5 kg, cassava stems 42800 nos. (214000 nos. sett cuttings) and sweet potato vine cuttings 38.6 lakh were distributed to the tribal farmers (Table 2). Apart from tuber crops quality planting materials vegetable seeds 18.6 kg, vegetable seed kits 1085 nos., maize seeds 70 kg, red gram seeds 66 kg, rice seeds 260 kg and ragi seeds 26 kg were also distributed to the tribal farmers under TSP programme.

Table 2. Year-wise quality planting/seed materials distributed to the tribal farmers under TSP

Year	Elephant foot yam tubers (kg)	Greater yam tubers (kg)	Taro tubers (kg)	Yam bean seeds (kg)	Cassava stem (Nos.)	Sweet potato vine cuttings (Lakh)	Sweet potato tubers (kg)	Maize seeds (kg)	Vegetable seeds (kg)	Red gram seeds (kg)	Rice seeds (kg)	Ragi seeds (kg)
2012-13	-	9800	2600	150	8000	1.2	-	-	-	-	-	-
2013-14	8000	6000	6000	100	1800	1.0	-	-	-	-	-	-
2014-15	6800	3900	10000	100	5000	1.2	2080	-	13	26	260	26
2015-16	6500	1000	-	100	6000	-	-	-	-	-	-	-
2016-17	3000	1000	-	75	5000	1.0	-	-	-	-	-	-
2017-18	-	3000	-	52.5	-	0.5	-	-	5.6 kg	-	-	-
2018-19	-	3000	-	100	5000	2.0	-	10	300 Nos. kits	10	-	-
2019-20	2000	2000	200	20	3000	1.5	-	20	60 Nos. kits	10	-	-
2020-21	4000	4000	500	25	3000	12.1	-	20	125 Nos. kits	10	-	-
2021-22	4500	35800	700	100	6000	18.1	-	20	600 Nos. kits	10	-	-
Total	**34800**	**69500**	**20000**	**822.5**	**42800**	**38.6**	**2080**	**70**	**18.6+1085**	**66**	**260**	**26**

During the year 2012-22, improved high yielding biofortified varieties of tuber crops and resource use efficiency of tuber crops technologies were demonstrated in the farmes fields which covered sweet potato 67.3 ha (both vine cuttings and tubers), yam bean 82.3 ha, *Colocasia* 20.0 ha, greater yam 34.8 ha, elephant foot yam 7.0 ha and cassava 21.4 ha. In addition to tuber crops, maize and red gram were introduced as intercrops in greater yam and sweet potato, respectively. Rice and ragi seeds were also distributed for cultivation as sole crops, as a component of farming system. Animal components poultry birds, ducks and piglets also distributed as a part of farming system components.

6.2. Livestock

Livestock are integral part of livelihood improvement programmes. Under TSP, during 2012-22, 6220 Vanaraja and Kalinga Brown poultry birds were distributed to the tribal farmers for livelihood improvement (Photo 24). Similarly, 750 Campbell Brown ducks, 120 pigs and 109 Black Bengal goats were distributed to the tribal farmers (Table 3) (Photo 25). In general, the income from livestock component was higher than crop components. However, the preference of livestock species depends upon the location.

Photo 24. Chicks distribution to Odisha farmers

Table 3. Year-wise number of livestock distributed to the tribal farmers

Year	Poultry	Duck	Pig	Goat
2014-15	200	200	-	-
2015-16	1350	550	120	-
2016-17	-	-	-	10
2017-18	-	-	-	-
2018-19	2000	-	-	-
2019-20	800	-	-	-
2020-21	1000	-	-	99
2021-22	870	-	-	-
Total	6220	750	120	109

Photo 25. Pig distribution to the Jharkhand farmers

6.3. Duck-shed

During the year 2015-16, 55 numbers of duck-sheds were constructed and handover to tribal farmers for housing the ducks (Photo 26 and 27).

Photo 26. Duck-shed constructed in the tribal farmers backyard

Photo 27. Duck-shed constructed under the project

6.4. Raised cement floor for goat keeping

Goat farming is highly profitable but at the same time the goats are highly susceptible to variety of diseases. This is because of improper housing. Improper cleaning/ removal of dung and urine in mud floor led to diseases in goats. Hence, it was decided to construct raised cement floor for keeping goats so that the floor can be cleaned properly and can avoid diseases. Under TSP, raised cement floor for goat was constructed in 57 tribal houses Burhakocha village in Ranchi district, Jharkhand (Table 4) (Photo 28).

Photo 28. Raised cement floor for goat keeping at Burhakocha, Ranchi, Jharkhand

Table 4.List of beneficiaries of ICAR-CTCRI TSP for tuber crops and raised goat floor at Burhakocha, Angara, Ranchi, Jharkhand.

Sl. No.	Name of beneficiary	Father's/ Husband name	GPS Location	
			Noth	East
1	Dev Charan Bedia	Late SukwaBedia	23°31.804'	085°25.245'
2	Dinesh Bedia	Sugan Bedia	23°24.110'	085°35.991'
3	Ajit Bedia	Sonaram Bediya	23°24.112'	085°35.989'
4	Budheshwar Bediya	Salikhram Bediya	23°24.099'	085°35.999'
5	Baleshwar Bedia	Lt.Pusuva Bediya	23°24.099'	085°35.984'
6	Mahdu Bedia	Mahatu Bedia	23°24.088'	085°35.987'

Sl. No.	Name of beneficiary	Father's/ Husband name	GPS Location	
			Noth	East
7	Balo Devi	Lt.Sardhu Bedia	23°24.090'	085°35.984'
8	Anand Bedia	Jaynarayan Bedia	23°24.123'	085°35.010'
9	Lakhiram Bediya	Lt.Gobara Bediya	23°24.022'	085°35.668'
10	Bijali Devi	Lakhiram Bediya	23°24.024'	085°35.670
11	Mangali Devi	Kaleshwar Bediya	23°24.008'	085°35.660'
12	Dhurendra Bediya	Bharat Bediya	23°24.076'	085°35.961'
13	Madhwa Bediya	LT.Jatal Bediya	23°24.038'	085°35.736'
14	Samli Devi	Raju Bediya	23°23.962'	085°35.969'
15	Anita Devi	Sanjay Bediya	23°24.999'	085°35.099'
16	Bala Devi	Lt.Balakram Bediya	23°24.098'	085°35.995'
17	Kartik Bediya	Lt.Dasaiya Bediya	23°24.004'	085°35.894'
18	Rijhan Devi	Ghasiram Bediya	23°24.087'	085°35.971'
19	Sawni Devi	Bhajanlal Bediya	23°24.087'	085°35.971'
20	Rimni Devi	LT.Jitu Bediya	23°24.076'	085°35.957'
21	Sunita Devi	Surendra Bediya	23°24.075'	085°35.969'
22	Khelu Bedia	Balu Bediya	23°24.065'	085°35.982'
23	Balo Devi	Pustam Bediya	23°24.068'	085°35.983'
24	Balo Devi	Lt.Baudhi Bediya	23°24.059'	085°35.970'
25	Atwari Devi	Dashrath Bediya	23°24.062'	085°35.966'
26	Jagarnath Bediya	Pradhan Bediya	23°24.063'	085°35.956'
27	Ramesh Bediya	Balku Bediya	23°24.060'	085°35.974'
28	Surodhani Devi	Savna Bediya	23°23.956'	085°35.921'
29	Aghani Devi	Bhola Bediya	23°23.950'	085°35.933'
30	Bairso Devi	Jangal Bediya	23°23.988'	085°35.958'
31	Kalamani Devi	Khadiya Bediya	23°23.980'	085°35.950'
32	Sunita Devi	Jatru Bediya	23°24.001'	085°35.956'

Sl. No.	Name of beneficiary	Father's/ Husband name	GPS Location	
			Noth	East
33	Jaymani Devi	Dhrup Bediya	23°23.997'	085°35.956'
34	Kaleshwari Devi	Dasaiya Bediya	23°24.002'	085°35.967'
35	Pako Devi	Mahesh Bediya	23°23.995'	085°35.966'
36	Sima Devi	Chaitan Bediya	23°23.996'	085°35.983'
37	Suro Devi	Sukra Bediya	23°23.988'	085°35.985'
38	Duman Devi	Lakshman Bediya	23°23.983'	085°35.977'
39	Dhuro Devi	Sohrai Bediya	23°23.964'	085°35.975'
40	Saban Devi	Abhiram Bediya	23°23.947'	085°35.934'
41	Jitan Devi	Budhram Bediya	23°24.015'	085°37.903'
42	Jheri Bediya	Lt.Phagua Bediya	23°24.049'	085°35.956'
43	Lalo Devi	Soharay Bediya	23°24.064'	085°35.948'
44	Ghasni Devi	Lakhna Bediya	23°24.092'	085°35.969'
45	BiseshwarBediya	Lt.Mangla Ch. Bediya	23°24.106'	085°36.007'
46	Manga Bediya	Balram Bediya	23°24.102'	085°35.970'
47	Shiv Shankar Bediya	Sukwa Bediya	23°24.110'	085°35.974'
48	Manjo Devi	Ghurendra Bediya	23°24.078'	085°35.964'
49	Charki Devi	Maneshwar Bediya	23°24.108'	085 35.983
50	Madan Bediya	Sonaram Bediya	23°24.109'	085°35.983'
51	Dashmi Devi	Motiram Bediya	23.24.096'	085°35.993'
52	Mundri Devi	Chaita Bediya	23°24.022'	085°35.910'
53	Dashrath Bedia	Lt.Bishun Bediya	23°24.058'	085°35.885'
54	Sunwa Bediya	Lt.Mitu Bediya	23°24.058'	085°35.968'
55	Jiro Devi	Khetu Bediya	23°23.952'	085°35.579'
56	Ganesh Bediya	Kushal Bediya	23°23.981'	085°35.569'
57	Tileshwari Devi	Shankar Bediya	23°24.099'	085°35.988'

6.5. Small agricultural implements

To reduce the drudgery of field operations, small agricultural implements were distributed to the tribal farmers. Sprayers 539, hand hoe 717, sickle 717, crow bar 717, pickaxe 717 and spade 688 numbers were distributed to the tribal farmers (Table 5) (Photo 29, 30 and 31). In addition to the above, cultivator 118 and garden hoe 118 were also distributed to the tribal farmers. As the tribal farmers' fields are adjacent to the forest, to protect tuber crops from animals, GI mesh fencing material 3370 kg was distributed to the tribal farmers (Table 5) (Photo 32).

Table 5. Small agricultural implements distributed

Year	Sprayer	Hand hoe	Sickle	Crow bar	Pickaxe	Spade	Cultivator	Garden hoe	GImesh
2014-15	3	29	29	29	29	-	-	-	1160
2015-16	10	68	68	68	68	68	68	68	2160
2016-17	3	50	50	50	50	50	50	50	50
2020-21	-	47	47	47	47	47	-	-	-
2021-22	523	523	523	523	523	523	-	-	-
Total	**539**	**717**	**717**	**717**	**717**	**688**	**118**	**118**	**3370**

Photo 29. Sprayer distributed to the tribal farmers of Nuaguda village in Koraput district of Odisha

Photo 30. Sprayer distributed to the tribal farmers of Kuinpada village in Kandhamal district of Odisha

Photo 31. Small agricultural implements distributed to the tribal farmers of Nuaguda village in Koraput district of Odisha

Photo 32. Fencing materials distributed to the tribal farmers of Kuinpada village in Kandhamal district of Odisha

6.6. Solar pumpset

Most of the tribal villages are in remote areas and inaccessible and in disadvantaged locations. Many of the fields, though located near water resources, due to lack of electricity supply, farmers are unable to exploit irrigation potential. Keeping the above, during 2016-17, a solar pump set was installed in Dayanidhiguda village, Koraput Block, Koraput District, Odisha and during 2017-18, a solar pump set was installed in Ranchi district, Jharkhand for irrigating the crops during dry spell and also to cultivate crops during *rabi* season (Photo 33 and 34). Protecting the crops from droughts as well as increasing cropping intensity by cultivating *rabi* crops increased the farm yield, income and farmers livelihood.

Photo 33. Solar pump-set at Burahkocha village, Ranchi district of Jharkhand

Photo 34. Solar pump-set at Burahkocha village, Ranchi district of Jharkhand

7. CAPACITY BUILDING

7.1. Trainings organized

Trainings were organized to tribal farmers on scientific methods of tuber crops cultivation and value addition regularly. During monitoring of demonstration also farmers were trained on tuber crops cultivation and other components like poultry, duckery, goatery, piggery, mushroom and honey bee farming. Dr. R.S. Misra, Dr. R.C. Ray, Dr. A. Mukherjee, Dr. M. Nedunchezhiyan, Dr. K. Laxminarayana, Dr. K.R. Rao, Dr. Kalidas Pati, Dr. V.B.S. Chauhan, Mr. K. Hanume Gowda, Mr. V.V. Bansode, Dr. R. Arutselvan,Mr. N.C. Jena, Mr. Niranjan Patnaik, Mr. B.K. Sahoo, Mr. P.K. Mati, Mr. B.B. Das, Dr. S.K. Jata, Mr. Kesab Paikray and Dr. K. Raja from the Regional Centre of ICAR-CTCRI, Bhubaneswar, Dr. M. Ananatharaman, Dr. S. Ramanathan, Dr. J.T. Sheriff, Dr. M.S. Sajeev, Dr. M.N. Sheela, Dr. G. Byju, Dr. T. Makeshkumar, Dr. M.L. Jeeva and Dr. P.S. Sivakumar from ICAR-CTCRI, Thirivananthapuram, scientists from ICAR institutes in Odisha, Jharkhand and Chhattisgarh, and scientists and faculty members from Odisha University of Agriculture and technology (OUAT), KVK, Ramakrishna Mission Ashrama, Ranchi as well as officers from Directorate of Horticulture Odisha were also involved in imparting training to the tribal farmers. A total of 4068 tribal farmers (men 2505 and women 1563) were trained during the reporting period. The details of trainings were given in Table 6.

Table 6. Details of training programmes conducted

Year	Title of training	No of participants		
		Male	Female	Total
2012-13	Improved package of practices and value addition in tuber crops (3 Nos.)	70	40	110
2013-14	Root and tuber crops production and value addition (8 Nos.)	220	150	370
2014-15	Root and tuber crops production and value addition (9 Nos.)	300	169	469
2015-16	Tuber crops-based cropping/farming systems for enhancing profitability (8 Nos.)	80	50	130
2016-17	Tuber crops-based cropping/farming systems for enhancing profitability (8 Nos.)	220	129	349
2017-18	Tuber crops-based cropping/farming systems for enhancing profitability (4 Nos.)	210	110	320
2018-19	Tuber crops-based cropping/farming systems for enhancing profitability (8 Nos.) and a Tuber crops day	575	325	900
2019-20	Tuber crops-based cropping/farming systems for enhancing profitability (4 Nos.)	200	120	320
2020-21	Tuber crops-based cropping/farming systems for enhancing profitability (6 Nos.)	105	195	300
2021-22	Tuber crops-based cropping/farming systems for enhancing profitability (16 Nos.)	525	275	800
	Total	**2505**	**1563**	**4068**

7.1.1. Details on trainings(2012-13)

- A training programme was conducted at Ramakrishna Mission, Narayanpur, Jharkhand during 8-9th August, 2012 on 'Improved package of practices and value addition in tuber crops'. Dr. R.S. Misra, Dr. R.C. Ray and Dr. S. Ramanathan have participated to impart the training (Photo 35).
- A training cum exposure visit was conducted to tribal farmers of Jharkhand and Chhattisgarh on 'Improved package of practices and value addition in tuber crops' during 10-12th October, 2012. Besides the scientists of Regional Centre of CTCRI, Bhubaneswar, Dr. M. Anantharaman from ICAR-CTCRI, Thiruvananthapuram also attended to impart the training to tribal farmers.
- A training cum exposure visits on 'Improved package of practices and value addition in tuber crops' was conducted to the tribal farmers of Kandhamal and Koraput districts at Regional Centre of CTCRI, Bhubaneswar during 22-24th November, 2012. Besides all the scientists of Regional Centre, Dr. J.T. Sheriff from ICAR-CTCRI, Thiruvananthapuram has participated to impart the training (Photo 36).

Photo 35. Interaction with Jamtada, Deogarh farmers on 23.08.12

Photo 36. Training at Bandhakamana village, Kandhamal district on 10.01.2013

7.1.2. Details on trainings (2013-14)

- During 2013-14, capacity building training programmes were organized for the tribal farmers, three in Ranchi district, two in Narayanpur districts and one each in Kandhamal and Koraput districts on root and tuber crops production and value addition (Photo 37).
- Two exposure visits for the tribal farmers (one each for Odisha and Jharkhand state) to the Regional Centre of ICAR-Central Tuber Crops Research Institute, Bhubaneswar were organized to train the tribal farmers on root and tuber crops production and value addition.

Photo 37. Training farmers in Ranchi, Jharkhand

- An exposure visits for the tribal farmers of Chhattisgarh state to the Regional Centre of ICAR-Central Tuber Crops Research Institute, Bhubaneswar was organized to train the tribal farmers on root and tuber crops production and value addition from 07.10.2013 to 09.10.2013. Dr. S.K. Chakrabarti, Director ICAR-CTCRI, Thiruvananthapuram has distributed certificates in the valedictory function to the tribal farmers (Photo 38).

Photo 38. Dr. S.K. Chakrabarti, Director, ICAR- CTCRI distributing certificate to Jharkhand women tribal farmers during their exposure visit to Regional Centre of ICAR-CTCRI

- An exposure visit to the Regional Centre of ICAR-CTCRI by tribal farmers from Kandhamal and Koraput during 28.12.13 to 30.12.13. Dr. S.P. Ghosh, formerly DDG (Hort), ICAR, New Delhi and Mr. Suresh Pattanaik, Consultant, OTELP, Bhubaneswar and Smt. Arunima, Joint Secretary, ORRISSA (NGO) attended the inaugural function (Photo 39).

Photo 39. An exposure visitof tribal farmers from Kandhamal and Koraput districts during 28.12.13 to 30.12.13. Dr. S.P. Ghosh, formerly DDG (Hort), ICAR, New Delhi and Mr. Suresh Pattanaik, Consultant, OTELP, Bhubaneswar and Smt. Arunima, Joint Secretary, ORRISSA (NGO) attended the inaugural function.

7.1.2. Details on trainings (2014-15)

- Five numbers of training programmes were organized on root and tuber crops production and value addition at Ranchi, Abujmarh, Kandhamal, Koraput and Bhubaneswar.
- Two one day trainings each at Gurgurjhari and Kulli villages were organized in Ranchi district, Jharkhand state in collaboration with Ramakrishna Mission, Ranchi on root and tuber crops production and value addition (Photo 39a).

Photo 39a. Dr. M. Anantharaman interacting with tribal farmers in Ranchi, Jharkhand

- A three days training programme was organized for tribal farmers of Jharkhand and at Regional Centre of ICAR-CTCRI, Bhubaneswar on root and tuber crops production and value addition.
- A three days training programme was organized for tribal farmers of Kandhamal and Koraput districts of Odisha state at Regional Centre of ICAR-CTCRI, Bhubaneswar on root and tuber crops production and value addition.
- Kisan Gosthi and training on tuber crop technologies were conducted at RKM, Narayanpur, and Orcha in Chattisgarh (Photo 39b and 39c).
- A training programme on "Livelihood improvement through tuber crops" was organized under Tribal Sub Plan at Barwatoli village, Angara (Block), Ranchi (District), Jharkhand state on 19.05.2014 (Photo 40). The training programme was facilitated by Ramakrishna Mission, Ranchi. Dr. R.S. Misra, Head, Dr. M. Nedunchezhiyan, Principal Scientist and Dr. Kalidas Pati from the Regional Centre of CTCRI, Bhubaneswar and Dr. Rajesh Kumar, SMS (PP), DKVK,

Photo 39b. Kisan Gosthi, interaction with tribal farmers in Narayanpur, Chhattisgarh

Photo 39C. Kisan Gosthi interaction with tribal farmers in Orcha, Chhattisgarh

RKM, Ranchi and Dr. Brijesh Pandey, SMS (PP), DKVK, RKM, Ranchi were acted as resource persons. The training programme was attended by 46 tribal farmers. Dr. R.S. Misra explained the farmers about importance of tuber crops in food and nutritional security. Further he explained the importance of elephant foot yam as cash crop. Dr. M. Nedunchezhiyan imparted training on agro-techniques of elephant foot yam, taro, yam, yam bean and sweet potato. He also imparted training on pests and diseases and value addition of tuber crops. Dr. K. Pati imparted training on yam bean cultivation, pest and disease management and value addition. After that Dr. R.S. Misra demonstrated 'Fungal diseases management in elephant foot yam'. Cow dung slurry was prepared and *Trichoderma* was mixed in the slurry. Elephant foot yam tubers were cut in to 500 g weight pieces. The cut pieces were dipped in the *Trichoderma* mixed cow dung slurry for 30 minutes and then removed and dried in the shade. The farmers were asked to plant the tubers one day after treatment in the pits. Method of pit preparation and planting were demonstrated to the farmers.The training programme was concluded with the vote of thanks by Mr. Brijesh Pandey.

Photo 40. Dr. R.S. Misra imparting training to the farmers of Barwatoli village, Ranchi

- A training programme on "Livelihood improvement through tuber crops" was organized under Tribal Sub Plan at Gurgurjari village, Ranchi (District), Jharkhand state on 23.05.2014 (Photo 41). The training programme was facilitated by Ramakrishna Mission, Ranchi. Dr. R.S. Misra, Head, Dr. M. Nedunchezhiyan, Principal Scientist and Dr. Kalidas Pati from the Regional Centre of Central Tuber Crops Research Institute, Bhubaneswar and Dr. Brijesh Pandey, SMS (PP), DKVK, RKM, Ranchi were acted as resource persons. The training programme was attended by 46 tribal farmers (15 female + 21 male farmers). Dr. R.S. Misra explained the farmers about importance of tuber crops in food and nutritional security. Further, he explained the importance of elephant foot yam as cash crop. Dr. M. Nedunchezhiyan imparted training on agro-techniques of elephant foot yam, taro, yam, yam bean and sweet potato. He also imparted training on pests and diseases and value addition of tuber crops. Dr. K. Pati imparted training on yam bean cultivation, pest and disease management and value addition. After that method of planting was demonstrated to the farmers. Tuber treatment with cow dung slurry and *Trichoderma* was demonstrated to the farmers. Elephant foot yam tubers were cut in to 500 g weight pieces. The cut pieces were dipped in the *Trichoderma* mixed cow dung slurry for 30

Photo 41. Training programme at Gurgurjari village, Ranchi district

minutes and then removed and dried in the shade. The farmers were asked to plant the tubers one day after treatment in the pits. Method of pit preparation and planting were demonstrated to the farmers. The farmers were asked to do mulching with the dried leaves and paddy straw immediately after planting elephant foot yam. The farmers were also advised to mulch immediately after planting of yam and taro also for uniform and early establishment of tubers.The training programme was concluded with the vote of thanks by Mr. Brijesh Pandey.

7.1.4. Details on trainings (2015-16)

- A training programme on root and tuber crops production and value addition was organized at Barkigorang village, Ranchi District, Jharkhand on 17.07.2015 (Photo 42).
- A training programme on 'Farming system involving tuber crops' was organized at Badagoan village, Pottangi block, Koraput district, Odisha on 12.09.2015 (Photo 43).
- A training programme on 'Farming system involving tuber crops' was organized at Kuinpada village, Chakapada block, Kandhamal district, Odisha on 16.09.2015 (Photo 44).

Photo 42. Dr. M. Nedunchezhiyan, imparting training to the farmers of Barkigorang village, Ranchi district

Photo 43. Training at Badagaon village Koraput district

Photo 44. Farming system involving tuber crops training at Kuinpada village, Kandhamal

- A three days training cum exposure visit for the tribal farmers of Jharkhand on 'Farming system involving tuber crops for livelihood improvement' to the Regional Centre of ICAR-CTCRI, Bhubaneswar was organized during 21-23 December 2015 (Photo 45 and 46).

Photo 45. Paddy straw mushroom training for Jharkhand tribal farmers

Photo 46. Honey bee training for Jharkhand tribal farmers

7.1.5. Details on trainings (2016-17)

- A training programme on 'Farming system involving tuber crops' was organized at Khanjaguda village, Chakapada Block, Kandhamal district, Odisha on 18.8.16. More than 40 tribal women and 20 men participated (Photo 47).
- A training programme on 'Farming system involving tuber crops' was organized at Nuaguda village, Pottangi Block, Koraput district, Odisha on 29.12.16 More than 40 tribal women and 30 men participated (Photo 48).

47. Training programme at Khanjaguda village, Kandhamal district, Odisha

Photo 48. Farming system involving tuber crops training at Khanjaguda village, Kandhamal district

7.1.6. Details on trainings (2017-18)

- Four numbers of on-farm trainings were conducted for capacity building of tribal farmers on Tuber crops-based farming system. In the training programme tribal farmers were trained on tuber crops cultivation, cereals, pulses, poultry, duckery cultivation. Farmers were also trained on value addition of tuber crops. Live demonstrations were conducted on chips and snack food production from sweet potato and cassava (Photo 49).

Photo 49. Training on value addition of tuber crops at Dadrisahi village, Kandhamal district of Odisha

7.1.7. Details on trainings (2018-19)

For capacity building of the tribal farmers on tuber crops-based farming system, eight nos. of on-farm training were organized to 200 tribal farmers belongs to Mohana block (Dimirijholi, Jubagaon, Andiragada and Anangadongra villages) and R.Udayagiri block (Kharipada, Sinisingh, Patrabasa Nayak Sahi and Lubursingh villages) of Gajapati district, Odisha (Photo 50 and 51). The trainings were conducted from pre-planting to harvesting at regular intervals. In the training farmers were trained on tuber crops cultivation, cereals and pulses cultivation, poultry farming and vegetable cultivationfor tuber crops-based farming system (0.2 ha model). Training on tuber crops value addition also imparted to farmers.

Photo 50. Training at Kharipada village, GUdayagiri block of Gajapati district, Odisha

Photo 51. Training at Dimirijholi village, Mohana block of Gajapati district, Odisha

7.1.8. Details on trainings (2019-20)

For capacity building of the tribal farmers on tuber crops, cereals, pulses cultivation and value addition of tuber crops, four nos. of on-farm training were organized on 'Tuber crops-based farming system' to cover 320 tribal farmers. One training during July and another during December were

Photo 52. Tuber crops training programme in Kandhamal district of Odisha

Photo 53.Tuber crops training programme in Kandhamal district of Odisha

organized for the tribal farmers of Budukakhol, Bandhakhamana and Kharijhola villages of Chakapada (Block), Kandhamal (District), Odisha (Photo 52 and 53). Similarly, one training during July and another during December were organized for the tribal farmers of Andragada, Jubagaon, Ateli and Chandragiri villages of Mohana (Block), Gajapati (District), Odisha. During training, farmers were trained on tuber crops and other cereals, pulses production and value addition of tuber crops (Photo 54).

Photo 54.Tuber crops value addition training programme in Kandhamal district of Odisha

7.1.9. Details on trainings (2020-21)

Six numbers of capacity building trainings were conducted on Tuber crops-based farming system to the 300 number of tribal farmers of Phalsipadar, Bujilimendi, Budhapadara, Nediguda, Kantiadhia and Jharkedi villages of Chakapada (Block), Kandhamal district. First two trainings were organized in the month of June and July while supplying tuber crops and other seed materials. During the training, farmers were trained on method of tuber crops and other cereals and pulses crops cultivation. Second two trainings were given during August and September mainly on pest and disease management, intercultural operations, poultry production and goat production technologies (Photo 55). Third two trainings were organized on tuber crops processing and value addition. In the village

Photo 55. Tuber crops-based farming system training programme in Kandhamal district of Odisha

tuber crops value addition demonstrations were conducted and trained them to make chips and snack foods from sweet potato and cassava.

7.1.10. Details on trainings (2021-22)

Sixteen numbers of capacity building training on tuber crops cultivation and value addition were organized and covered 800 tribal farmers. Eight numbers of training were organized in the month of July and August in eight blocks one each in Pottangi and Semiliguda blocks of Koraput district, Bissam Cuttack and Minuguda blocks of Rayagada district, Kotagarh, Tumidibhanda, Phiringia

Photo 56. Tuber crops-based farming system training programme at Madaguda village in Kandhamal district of Odisha

and Chakapada blocks of Kandhamal district (Photo 56 and 57). During the training, farmers were trained on tuber crops cultivation method, mid-season corrections, pest and disease management. Vegetable seeds were also given to raise the crop for supplementing farm income and they were trained on vegetable crop production also. Another eight numbers of trainings were organized to demonstrate value added product development at village level in eight blocks one each in Pottangi and Semiliguda blocks of Koraput district, Bissam Cuttack and Minuguda blocks of Rayagada district, Kotagarh, Tumidibhanda, Phiringia and Chakapada blocks of Kandhamal district. Tribal farmers were shown, how to produce chips and snack foods from sweet potato and cassava.

Photo 57. Tuber crops-based farming system training programme at Khirajola village in Koraput district of Odisha

7.2. Tuber day

7.2.1. Tuber day (2018-19)

A 'Tuber day' was organized on 09.01.2019 at Chandragiri (Village), Mohana (Block), Gajapati (District), Odisha (Photo 58). Dr. James George, Project Coordinator, AICRPTC, ICAR-CTCRI, Thiruvananthapuram was the chief guest for the function. Dr. M. Nedunchezhiyan, Principal Scientist and Head(i/c) coordinated the programme. Dr. K. Laxminararayana, Principal Scientist, Dr. Kalidas Pati, Dr. V.B.S. Chauhan and Mr. V.V. Bansode Scientists participated in the Tuber day. Scientists from KVK, R.Udayagiri and Line department officers from state govt. were also participated in the event. Representatives from the NGOs viz., ISARA (Institute of Social Action and Research Activities) and SACAL (Social Action for Community Alternative Learning) also participated in the programme and address the gathering. Around 500 tribal farmers and farm women from 30 villages attended the

programme. In Tuber day, the importance of tuber crops under climate change scenario and role of tuber crops in food and nutrition security was deliberated and discussed with the farmers. Tuber crops exhibition also organized to show case the tuber crops technologies. Live specimens of various tuber crop varieties were also displaced in the exhibition.

Photo 58. Tuber day celebration on 09.01.2019 at Chandragiri (village), Mohana (block), Gajapati (district), Odisha.

Among 200 tribal farmers, the best five farmers were awarded for encouragement and active participation in the 'Tuber crops based integrated farming system' demonstration conducted in Gajapati district of Odisha. The best three exhibits displayed during the 'Tuber day' were also awarded.

7.2.2. Tuber day (2019-20)

The Regional Centre of ICAR-Central Tuber Crops Research Institute, Bhubaneswar has organized 'Tuber Day' at Tikabali, Kandhamal district, Odisha on 17.01.2020 (Photo 59). Dr. V. Ravi, Director (Acting), Dr. M.S. Sajeev, Principal Scientist and Dr. M. Anantharaman, Retd Principal Scientist, ICAR-CTCRI, Thiruvananthapuram, Dr. M. Nedunchezhiyan, Principal Scientist & Head, Dr. Kalidas Pati, Dr. V.B.S. Chauhan, Mr. V. Bansode, Scientists, Dr. S.K. Jata, JFS, Regional Centre of ICAR-CTCRI, Bhubaneswar participated in the tuber day meeting (Photo 60). Scientists from all other ICAR institutes also attended the meeting.

Tuber crops play important role in food and economic security of tribal population in Odisha. Tuber day is an attempt to make aware about production of quality planting materials, scientific

production technologies, value added products, food and nutritional security said Dr. V, Ravi (Acting Director), ICAR-CTCRI, Thiruvananthapuram, Kerala to the farmers. Tuber day highlighted the nutritional value of the tuber crops and importance of value-added products developed from different tuber crops particularly biofortified β-carotene rich orange flesh and anthocyanin rich purple flesh sweet potato varieties, development of seed villages for providing sufficient quality planting materials

Photo 59. Tuber day celebration at Tikabali, Kandhamal district of Odisha

Photo 60. Tuber day celebration at Tikabali, Kandhamal district of Odisha

to the tribal community said Dr. M. Nedunchezhiyan, PI &Head (I/C) of Regional Centre, ICAR-CTCRI, Bhubaneswar, Odisha to the farmers.

Scientist from different Institutes like ICAR-CTCRI, ICAR-NRRI, ICAR-CIWA, OUAT and NGO (ORRISSA), briefed about the importance of tuber crops cultivation, value added products, dry land agriculture, rice-tuber crops ecosystem, water use efficiency under changing climatic conditions and clarified the farmer's doubts in farmers-scientists interaction. DDH, Kandhamal provided information about different schemes of Odisha state horticulture department. The progressive tuber crops farmers were showcasing their tuber crops materials in the exhibition stall and also awarded and facilitated tuber crops tribal farmers during the programme (Photo 61). Around 500 tribal farmers participated in the programme.

Photo 61. Tuber day celebration at Tikabali, Kandhamal district of Odisha

7.2.3. Tuber day (2020-21)

A tuber day was celebrated on 22.03.2021 at Mohana, Gajapati district of Odisha. Dr. M. Nedunchezhiyan, PS, PI & Head i/c organized the programme (Photo 62). Dr. Kalidas Pati and Dr. V.B.S. Chauhan, Scientists, Regional Centre of ICAR-CTCRI, Bhubaneswar, Dr. S.K. Jata, JFS participated in the tuber crops day. The SACAL (NGO) facilitated the programme. Representatives from Directorate of Horticulture, Taptapani Farmers Producer Organization and press and media people attended the meeting. More than 300 tribal farmers attended the programme (Photo 63). Dr. M. Nedunchezhiyan,

Photo 62. Tuber day celebration on 22.03.2021 at Mohana, Gajapati district of Odisha

Photo 63. Tuber day celebration on 22.03.2021 at Mohana, Gajapati district of Odisha

PS, PI & Head i/c explained importance of root and tuber crops in food and nutrition security. He also outlined the project activities and achievements. Dr. Kalids Pati, Scientist explained to the farmers about improved varieties of tuber crops as well as bio-fortified varieties (Photo 64). Dr. V.B.S. Chauhan, Scientist, outlined the role of tuber crops in the climate change. Dr. S. K. Jata, JFS, explained package of practices of important root and tuber crops. The beneficiary tribal farmers also exhibited their tuber crops produce. In the 'tuber day' programme, best farmer award to five tribals were given (Photo 65). Similarly, best exhibits award also given to three farmers.

Photo 64. Tuber day celebration on 22.03.2021 at Mohana, Gajapati district of Odisha

Photo 65. Tuber day celebration on 22.03.2021 at Mohana, Gajapati district of Odisha

7.2.4. Tuber day (2021-22)

The Regional Centre of ICAR-Central Tuber Crops Research Institute (CTCRI), Bhubaneswar has organized 'Tuber Day' under the project 'Tribal Sub Plan (TSP)' on 22.03.2022 at Tikabali, Kandhamal district, Odisha (Photo 66). Shree Prasant Kumar Satapathy, Chief District Agricultural Officer, Kandhamal was the chief guest for the programme. Dr. R.C. Ray, Principal Scientist (Retd), Regional Centre of ICAR-CTCRI, Bhubaneswar, Shree Mihir Samantaray, Deputy Director of Horticulture, Kandhamal, Dr. Subrat Kumar Behera, Chief Scientist, RRTTS, OUAT, Kandhamal were the Guest of honour for the programme. Shree Anil Kumar Patnayak, Block Development Officer, Shree Premananda Mohapatra, Secretary, ORRISSA (NGO) and Shree Sujit Kumar Padhy, AAO, Tikabali were graced the occasion. Around 500 tribal farmers participated in the programme. Dr. K. Laxminarayana, Principal Scientist, Regional Centre of ICAR-CTCRI, Bhubaneswar welcomed the delegates. Dr. M. Nedunchezhiyan, Principal Scientist and PI (TSP), Regional Centre of ICAR-CTCRI, Bhubaneswar gave the brief presentation on Tribal sub plan activities. He highlighted that during the year 2021-22, the Regional Centre of ICAR-CTCRI has adopted 523 tribal farmers from Chakapad, Phiringia and Tumidibandha blocks of Kandhamal district, Kotagarh, Muniguda and Bissam Cuttack blocks of Rayagada district, and Semiliguda and Pottangi blocks of Koraput district of Odisha (Photo 67, 68 and 69). During the corresponding the year sweet potato 2250000 vine cuttings, greater yam 11800 kg, elephant foot yam 4500 kg, colocasia 700 kg, yam bean 100 kg , cassava 6000 stems, maize seed 20 kg, red gram 10 kg, vegetable seed kits 600 nos. (vegetable seed kits contain

Amaranthus, okra, chilli, cowpea, French bean, tomato, palak and *Dolichos* seeds), chicks 870 nos., small implements like spade 523 nos., pickaxe 523 nos., crowbar 523 nos., hand-hoe prong 523 nos., sickle 523 nos., and knapsack sprayer 523 nos. were distributed to the tribal farmers. Sixteen numbers of tuber crops cultivation and value addition, on-farm trainings were organized for the tribal farmers. In tribal farmers field, the average yield of sweet potato 14.2 t/ha, yam bean 20.5 t/ha, taro 13.5 t/ha, elephant foot yam 25 t/ha, maize 3250 kg/ha, ragi 1090 kg/ha, greater yam 26.2 t/ha. Each tribal household produced sufficient tubers, rice, ragi, maize, vegetables, meat etc.

The delegates spoken about the importance of tuber crops in food and nutritional security and livelihood, method of tuber crops cultivation and value addition. Tuber crops exhibition was also organized during the 'Tuber day' celebration. Fifty-two farmers brought their tuber samples and exhibited in the Tuber day. This Centre has facilitated 16 nos. of best tuber crop farmers among 523 farmers and also facilitated 4 nos. of best tuber exhibitors during the tuber day. On this occasion two leaflets on 'Saru patrapada rogho' (Taro leaf blight) and 'Kandamula gunipokho' (Sweet potato weevil) were released. Shree Raj Kumar Behera, ORRISSA (NGO) proposed vote of thanks.

Photo 66. Tuber day celebration on 22.03.2022 at Tikabali, Kandhamal district, Odisha

Photo 67. Tuber day celebration on 22.03.2022 at Tikabali, Kandhamal district, Odisha

Photo 68. Tuber day celebration on 22.03.2022 at Tikabali, Kandhamal district, Odisha

Photo 69. Tuber day celebration on 22.03.2022 at Tikabali, Kandhamal district, Odisha

8. RESULTS OF DEMONSTRATIONS CONDUCTED

As the beneficiaries were tribal farmers, as per guidelines of Indian Council of Agricultural Research (ICAR), tribal dominated districts were selected. Before selecting beneficiaries, discussion was carried out with Kisan Vigyan Kendra's (KVKs) and NGOs who were working in tribal areas of Odisha, Chhattisgarh and Jharkhand states. Front-line demonstrations (FLDs) on tuber crops and livestock technologies were laid out in the field after selecting the beneficiaries. Year-wise and state-wise number of beneficiaries were given in Table 7. A total of 1840 (Odisha-1184, Jharkhand-421 and Chhattisgarh-235) tribal farmers were benefitted from the TSP project during the reporting period.

8.1. Brief on demonstrations (2012-13)

During 2012-13, 300 beneficiaries were selected for laying out tuber crops demonstrations. In Odisha 75, Jharkhand 125 and Chhattisgarh 100 tribal farmers were selected for laying out front line demonstrations on various tuber crops. With the help of ORRISSA (NGO) in Kandhamal (Bandhakamana village, Chakapada block) and PRAGATI (NGO) in Koraput (Lendrimaliguda village,

Koraput block) districts of Odisha, the following quantity of tuber crops planting materials: cassava (Sree Prakash, Vellayani Hraswa, Sree Vijaya) 3000 stems, yam (Orissa Elite) 3000 kg, *Colocasia*/taro (Telia and Muktakeshi) 1000 kg, yam bean (RM-1) seeds 100 kg, sweet potato (Kishan, Kalinga, Gouri and Sankar) vine cuttings 100000 nos. were distributed to 75 tribal farmers for conducting 150 frontline demonstrations on improved varieties. With the help of Ramakrishna Mission, Deoghar, Jharkhand, the following quantity of tuber crops planting materials of cassava (Sree Prakash, Vellayani Hraswa, Sree Vijaya) 2500 stems, yam (Orissa Elite) 2000 kg, *Colocasia*/taro (Muktakeshi) 300 kg and yam bean (RM-1) seeds 25 kg, sweet potato (Kishan, Kalinga, Gouri and Sankar) cuttings 10000 nos., *Trichoderma* powder 200 kg) were distributed to 125 tribal farmers for conducting 150 front demonstrations in Deoghar, Dumka and Jamtada villages in Deoghar district of Jharkhand state. With the help of Ramakrishna Mission, Narayanpur in Abujmarh tribal area in Narayanpur district of Chhattisgarh state, the following quantity of tuber crops planting materials of cassava

Table 7. State and year wise number of tribal beneficiaries of tuber crops technologies

Year	No. of beneficiaries
2012-13	75 (Odisha), 125 (Jharkhand) 100 (Chhattisgarh)
2013-14	55 (Odisha) 75 (Jharkhand) 75 (Chhattisgarh)
2014-15	69 (Odisha) 52 (Jharkhand) 60 (Chhattisgarh)
2015-16	68 (Odisha) 55 (Jharkhand)
2016-17	88 (Odisha) 57 (Jharkhand)
2017-18	24 (Odisha) 57 (Jharkhand)
2018-19	200 (Odisha)
2019-20	35 (Odisha)
2020-21	47 (Odisha)
2021-22	523 (Odisha)
Total	**1840**

Photo 70. Colocasia (Telia) field at Jamtada village in Deogarh district of Jharkhand

Photo 71. Yam cultivation in Bandhakamana village in Kandhamal district of Odisha

(Sree Prakash, Vellayani Hrishwa, Sree Vijaya) 2500 stems, yam (Orissa Elite) 4800 kg, *Colocasia*/ taro (Telia and Muktakeshi) 1300 kg and yam bean (RM-1) seeds 25 kg, sweet potato (Kishan, Kalinga, Gouri and Sankar) cuttings 10000 nos., *Trichoderma* 200 kg were distributed to 100 tribal farmers for conducting 150 front line demonstrations.

Photo 72. Yam bean cultivation in Bandhakamana village in Kandhamal district of Odisha

The demonstrations were monitored by regular visiting the fields. *Colocasia* var. Telia is susceptible to leaf blight. Hence farmers were advised to spray sixer or saaf 1.5 g/litre of water at 60 and 90 days after planting as prophylactic measure. Sex pheromone traps were installed where sweet potato weevil infestation is severe. However, farmers were adivised to carry out earthing-up at 60 and 90 days after planting. Farmers were also advised to harvest the sweet potato as soon as cracks in the soil is noticed. Dr. R.C. Ray and Dr. M. Nedunchezhiyan visited Lendrimaliguda village in Koraput district and Bandhakamana village in Kandhamal district during 31.7.12 - 02.08.12 for monitoring the crop performance. Dr. (Mrs) A. Mukherjee and Dr. M. Nedunchezhiyan visited Deoghar, Jharkhand during 22.8.12 - 24.8.12 and visited the demonstration fields of tribal farmers in Deoghar, Dumka and Jamtada villages (Photo 70). Dr. R.C. Ray and Dr. K. Laxminarayana visited the demonstration plots at farmers' fields at Bandhakamana village in Kandhamal district of Odisha during 08.09.12-11.09.12. Dr. R.S. Misra and Dr. M. Nedunchezhiyan visited Bandhakamana village in Kandhamal district of Odisha for monitoring tuber crop demonstration plots from 11.12.12 to13.12.12 (Photo 71 and 72).

The tuber yield from all the three states was as follows: greater yam 22.3-24.2 t/ha, *Colocasia*/taro 14.3-15.8 t/ha, yam bean 13.4-15.3 t/ha, cassava 15.4-17.5 t/ha and sweet potato 11.6-12.4 t/ha. In general, the introduced improved varieties of tuber crops produced higher yield than local cultivars especially grown in certain demonstrated villages.

8.2. Brief on demonstrations (2013-14)

During the year 2013-14, Odisha, Jharkhand and Chhattisgarh states were selected for demonstrating tuber crops technologies for the livelihood improvement of tribal farmers. Kandhamal and Koraput districts in Odisha, Ranchi district in Jharkhand and Narayanpur district in Chhattisgarh were selected for conducting front line demonstrations. All these districts are dominated by tribals. In Jharkhand state, Ranchi district, Tigranayatoli village (40 tribals) and Tirlokocha village (35 tribals) were adopted. In Chhattisgarh state, Narayanpur district, Abujmarh75 tribal farmers were adopted. In Odisha state, Kandhamal district, Bandhakamana, Balumaha and Rangamatia villages were adopted with 30 tribal farmers and in Koraput district, Ekdelli village, Mahadevput (GP) was adopted with 25 tribal farmers. A total of 205 tribal farmers were selected for conducting demonstrations on tuber crops technologies. High yielding varieties were introduced as technological interventions. Quality planting materials of greater yam (Orissa Elite) 6000 kg, elephant foot yam (Gajendra) 8000 kg, taro (Muktakeshi) 6000 kg, yam bean (RM-1) 100 kg, sweet potato (Bhu Sona and Kishan) 100000 nos. of vinecuttings and cassava (Sree Jaya, Sree Vijaya and Vellayani Hraswa) 1800 stems were distributed to the tribal farmers (Table 8). The area covered in all the three states together were 3.0 ha under greater yam, 1.6 ha under elephant foot yam, 3.0 ha under taro, 10 ha under yam bean, 1.25 ha under sweet potato, 3.0 ha under *Colocasia*/taro and 0.9 ha under cassava (Table 9) (Photo 73).

Table 8. Quantity of planting materials of tuber crops distributed to the tribal farmers

State	Greater yam (kg)	Elephant foot yam (kg)	Sweet potato (vine cuttings)	Yam bean (kg)	Cassava (stems)	Colocasia (kg)
Odisha	4000	2000	100000	50	1000	2000
Jharkhand	1000	3000	-	25	400	2000
Chhattisgarh	1000	3000	-	25	400	2000
Total	**6000**	**8000**	**100000**	**100**	**1800**	**6000**

Table 9. Area (ha) covered by the tuber crops interventions

State	Greater yam (ha)	Elephant foot yam (ha)	Sweet potato (ha)	Yam bean (ha)	Cassava (ha)	Colocasia (ha)
Odisha	2.0	0.4	1.25	5.0	0.5	1.0
Jharkhand	0.5	0.6	-	2.5	0.2	1.0
Chhattisgarh	0.5	0.6	-	2.5	0.2	1.0
Total	**3.0**	**1.6**	**1.25**	**10.0**	**0.9**	**3.0**

The demonstrations were monitored by regularly visiting the fields. Elephant foot yam var. Gajendra is susceptible to collar rot and leaf blight. Hence, farmers were advised to spray sixer or saaf 1.5 g/litre of water at 60 and 90 days after planting as a prophylactic measure. Sex pheromone traps were installed where sweet potato weevil infestation is severe.The yields of tuber crops are presented in Table 10. Cultivation of greater yam var. Orissa Elite produced higher tuber yield of 22.9 t/ha compared to the other crops/interventions (Photo 74). This may be due to the suitability of this crop to climatic conditions of these states, varietal attributes and long duration of the crop compared to the other crops. The intervention, elephant foot yam (Gajendra) produced 20.2 t/ha and cassava (Sree Jaya, Sree Vijaya and Vellayani Hraswa) produced the next higher tuber yield of 18.3 t/ha. Taro (Muktakeshi) produced cormel yield of 13.1 t/ha. Yam bean (RM-1) produced tuber yield of 12.5 t/ha. This was the next higher yield. Sweet potato produced tuber yield of 12.4 t/ha. Short duration crops like sweet potato and yam bean produced lower yield. In general, the introduced improved varieties of tuber crops produced higher yield than local cultivars especially sweet potato, taro and greater yam. The higher farm productivity increased the farm production. The availability of roots and tubers for household consumption and sale increased. Household food and nutritional security was enhanced through increased availability, accessibility and utilization of nutritionally rich roots and tubers.

Higher net return of Rs 219000/ha was obtained with greater yam intervention followed by elephant foot yam Rs 186000/ha. Taro (Muktakeshi) gave net returns of Rs 116000/ha. This was the next best in terms of net return per unit area. Yam bean (RM-1) recorded net return of Rs 79500/ha. Net returns from sweet potato (Rs 35000/ha) and cassava (Rs 54000/ha) were lower. Higher cost benefit ratio of 2.76 was noticed with greater yam and yam bean. This was due to higher yield in greater yam and lower cost of cultivation in yam bean. Elephant foot yam recorded benefit cost ratio of 2.59. Taro (Muktakeshi) intervention generated benefit cost ratio of 2.44. Due to lower market price of sweet potato resulted in lower benefit cost ratio (2.30). Higher net returns from various tuber crops interventions resulted in higher farm income. The enhanced farm income due to higher productivity of high yielding varieties initiated tribal farmers to purchase additional livelihood needs. The tribal farmers livelihood was improved through tuber crops intervention. The cultivation of high yielding varieties of tuber crops like elephant foot yam, greater yam, yam bean, sweet potato, cassava and taro hold promise in the hilly and plateau regions of Odisha, Chhattisgarh and Jharkhand states of India. The study indicated that root and tuber crops play significant role in the improvement of livelihood security and income of tribal farmers.

Table 10. Yield and returns from tuber crops interventions

Crop	Number of demonstrations	Average demonstration area (m^2)	Average tuber yield (t /ha)	Gross return (Rs/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	Benefit: cost ratio
Greater yam (Orissa Elite)	148	200	22.9	343500	124500	219000	2.76
Elephant foot yam (Gajendra)	148	100	20.2	303000	117000	186000	2.59
Sweet potato cuttings(Bhu Sona and Kishan)	55	400	12.4	62000	27000	35000	2.30
Taro (Muktakeshi)	62	200	13.1	196500	80500	116000	2.44
Yam bean (RM-1)	200	400	12.5	124500	45000	79500	2.76
Cassava (Sree Jaya, Sree Vijaya and Vellayani Hraswa	200	200	18.3	91500	37500	54000	2.44

* Sale price of greater yam Rs 15/kg, elephant foot yam Rs 15/kg, sweet potato Rs 5/kg, taro Rs 15/kg, yam bean Rs 10/kg and cassava Rs 5/kg.

Photo 73. Greater yam and elephant foot yam field at Ekdelli (village), Koraput district of Odisha

Photo 74. A woman farmer with the harvested tubers of greater yam var. Orissa Elite at Ekdelli (village), Mahadevput (GP), Koraput district of Odisha

8.3. Brief on demonstrations (2014-15)

During the year 2014-15, tuber crops-based farming system was demonstrated in181 tribal farmers' fields in Odisha, Jharkhand and Chhattisgarh. In Odisha state, Kandhamal district, Mallickpada village (29 tribal farmers) and in Koraput district, Dayanidhiguda and Kendar villages (65 tribal farmers) were adopted (Photo 75 and 76). In Jharkhand, Gurgurjari village is having Oraon, Toppo, Bhagat tribes, in Kulli village is having Oraon, Tigga, Bhagat, Lokra, Tirki, and Kujur, and in Barkigorng village is having Bedia, Lohra and Munda tribes. In Jharkhand state, Ranchi district, Gurgurjari and Kulli villages (80 tribal farmers) were adopted. In Chhattisgarh, Narayanpur district, Abujmarh (80 tribal families) was adopted. Quality planting materials of elephant foot yam (Gajendra) 7500 kg, colocasia (Muktakeshi) 6000 kg, yam (Orissa Elite) 6000 kg, cassava (Sree Jaya and Sree Vijaya)

Photo 75. Farming system involving tuber crops (0.4 ha model) at Mallickpada village, Kandhmal district

Photo 76. Taro var. Muktakeshi cultivation at Mallickpada village, Kandhmal district of Odisha

stem 3500, yam bean (RM-1) 100 kg and sweet potato (Kishan, Gouri, Sankar and Bhu Sona) 1,10,000 vine cuttings were distributed to 181 tribal farmers of Odisha, Jharkhand and Chhattisgarh. Cereals (rice 26 kg and ragi 26 kg), pulses (red gram 26 kg), vegetable seeds (13 kg), poultry birds (Vanaraj 200 nos.) and ducks (Campbell Brown 200 nos.) also distributed to the farmers (Photo 77, 78 and 79). A demonstration on improved cultivation of elephant foot yam and disease management was conducted in one-acre area in Baruatoli village of Ranchi district.

Photo 77. A beneficiary with her chicks

Photo 78. Small agricultural implements given to tribal farmers

Photo 79. Farming system yield at Gurgurjari village, Jharkhand

The demonstrations were monitored by regularly visiting the fields. Elephant foot yam var. Gajendra is susceptible to collar rot and leaf blight. Hence, farmers were advised to spray sixer or saaf 1.5 g/litre of water at 60 and 90 days after planting as a prophylactic measure. Sex pheromone traps were installed where sweet potato weevil infestation is severe. The yield from various crop and animal components were as follows: greater yam 18.8-22.2 t/ha, Colocasia/taro 13.4-14.3 t/ha, yam bean 12.3-13.4 t/ha, cassava 14.5-16.5 t/ha and sweet potato 10.8-11.4 t/ha. The poultry birds gained weight 2.0-2.15 kg and layed 35-37 eggs per bird. The gross income from the farming system ranged from Rs 43520-44560 and net income ranged from Rs 29500-31150. In general, the introduced improved varieties of tuber crops produced higher yield than local cultivars especially grown in certain demonstrated villages.

8.4. Brief on demonstrations (2015-16)

During the year 2015-16, tuber crops-based farming system demonstration was laid out in 123 tribal farmer fields in Odisha and Jharkhand. 40 tribal beneficiaries in Kuinpada (vill), Bafalamendi B (GP), Chakapada (Block), Khandhamal (Dist), Odisha and 28 tribal beneficiaries from Badagaon (village), Pottangi, (Block), Koraput (Dist), Odisha and 55 tribal families from Barkigorang (village), Angara (Block), Ranchi (Dist), Jharkhand were identified. Quality planting materials of elephant foot yam (Gajendra) 6500 kg, greater yam (Orissa Elite) 1000 kg, yam bean (RM-1) 100 kg and cassava (Sree Jaya and Sree Vijaya) 6000 stems were distributed to the farmers. Along with crop component, animal component poultry bird Vanaraj 1350 nos., duck Khaki Campbell 550 nos. and piglets 120 nos. were also distributed to the tribal farmers. Poultry birds were distributed in Kandhamal and Koraput districts of Odisha, whereas ducks and piglets were distributed in Ranchi district of Jharkhand. The animal components were distributed as per location specific preference of the farmers.

In Badagaon (village), Pottangi, (Block), Koraput (Dist), Odisha, 28 tribal farmers were selected (Photo 80). As this village is in hill top and farmers were not preferring animal component, only crop component was included in the farming system (0.4 ha model). The details of crop components and their yield and economics were given in the Table 11. The demonstrations were monitored by regular visit to the fields. Elephant foot yam var. Gajendra is susceptible to collar rot and leaf blight. Hence, farmers were advised to spray sixer or saaf 1.5 g/litre of water at 60 and 90 days after planting as a prophylactic measure. Sex pheromone traps were installed where sweet potato weevil infestation is severe. The tuber crops-based farming system produced 1965 kg of rice equivalent yield, gross return of Rs 39300 and net return of Rs 25210/0.4 ha. Whereas rice alone produced 1010 kg of rice and net return of Rs 9200/0.4 ha (Table 12). Farming system involving tuber crops generated 12 man-days additional employment. Further the employment was spread throughout the year.

Table 11. Integrated farming system components yield and economics (0.4 ha) at Badagaon, Koraput, Odisha

Sl. No.	Crop/animal	Area (ha)	Yield (kg)	Rice equivalent yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	Employment generation (Man-days)
1	Rice	0.20	564	564	11280	5600	5680	46
2	Maize	0.03	56	42	840	280	560	4
3	Ragi	0.02	26	26	520	180	340	2
4	Redgram	0.02	13	32.5	650	180	470	2
5	Sweet potato	0.04	360	180	3600	1100	2500	4
6	Yam bean	0.03	370	277.5	5550	1300	4250	6
7	Greater yam	0.02	304	304	6080	2000	4080	12
8	Colocasia	0.02	266	266	5320	1300	4020	7
9	Elephant foot yam	0.008	96	96	1920	550	1370	3
10	Cassava	0.002	18	9	180	100	80	2
11	Vegetable (*Amaranthus*, Bhendi, bitter gourd, ridge gourd etc.)	0.01	168	168	3360	1500	1860	12
	Total	**0.4**	**2241**	**1965**	**39300**	**14090**	**25210**	**100**

*Sale price of rice Rs 20/kg, maize Rs 15/kg, ragi Rs 20/kg, redgram Rs 50/kg, sweet potato Rs 10/kg, yam bean Rs 15/kg, greater yam Rs 20/kg, colocasia Rs 20/kg, elephant foot yam Rs 20/kg, cassava Rs 10/kg andvegetables Rs 20/kg.

Table 12. Check/Control at Badagaon, Koraput, Odisha

Sl. No.	Crop/animal	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	Employment generation (Man-days)
1	Rice	0.4	1010	20200	11000	9200	88

*Sale price of rice Rs 20/kg

In Kuinpada (village), Chakapada (Block), Kandhamal (District), Odisha state, tuber crops-based farming system 0.4 ha model was laid out in 40 tribal farmers' fields (Photo 81 and 82). The components of farming system and their area of cultivation are given in the Table 13. The results revealed that tuber crops-based farming system produced 1415.6 kg of rice equivalent yield, gross returns of Rs 42460 and net returns of Rs 28120/0.4 ha. Whereas, rice alone produced 532 kg of rice and net returns of Rs 6960/0.4 ha (Table 14). Farming system involving tuber crops generated 24 man-days additional employment. Further, the employment was spread throughout the year.

Photo 80. Farming system involving tuber crops field at Badagaon village in Koraput district of Odisha

Table 13. Integrated farming system components yield and economics (0.4 ha) at Kuinpada, Kandhamal, Odisha

Sl. No.	Crop/animal	Area (ha)	Yield (kg)	Rice equivalent yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	Employment generation (Man-days)
1	Rice	0.20	287	287	8610	4800	3810	40
2	Maize	0.03	44	22	660	260	400	3
3	Ragi	0.02	24	16	480	150	330	2
4	Redgram	0.02	13	21.7	650	150	500	2
5	Sweet potato	0.04	345	115	3450	1000	2450	4
6	Yam bean	0.03	367	183.5	5500	1000	4500	4
7	Greater yam	0.02	293	195.3	5860	1600	4260	10
8	Colocasia	0.02	235	156.7	4700	1000	3700	6
9	Elephant foot yam	0.008	91	60.7	1820	500	1320	3
10	Cassava	0.002	14	4.7	140	100	40	2
11	Vegetable (*Amaranthus*, Bhendi, bitter gourd, ridge gourd etc.)	0.01	155	103.3	3100	1300	1800	10
12	Backyard poultry	20 (nos.)	43	172	5160	2000	3160	10
		Eggs	779	77.7	2330	480	1850	4
	Total	**0.4**	**1911**	**1415.6**	**42460**	**14340**	**28120**	**100**

*Sale price of rice Rs 30/kg, maize Rs 15/kg, ragi Rs 20/kg, redgram Rs 50/kg, sweet potato Rs 10/kg, yam bean Rs 15/kg, greater yam Rs 20/kg, colocasia Rs 20/kg, elephant foot yam Rs 20/kg, cassava Rs 10/kg, vegetables Rs 20/kg, poultry meat Rs 120/kg and egg Rs 3/egg.

Table 14. Check/Control at Kuinpada, Khandamal, Odisha

Sl. No.	Crop/animal	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	Employment generation (Man-days)
1	Rice	0.4	532	15960	9000	6960	76

*Sale price of rice Rs 30/kg

Photo 81. Farming system involving tuber crops field at Kuinpada village in Kandhamal district of Odisha

Photo 82. Dr. S.K. Chakraborti, Director, ICAR-CTCRI, Thiruvananthapuram inspecting yam bean tuber

Barkigorang (village), Angara (block), Ranchi (district), Jharkhand state, tuber crops-based farming system 0.4 ha model was laid out in 55 tribal farmers' fields (Photo 83, 84, 85 and 86). The components of farming system and their area of cultivation were given in the Table 15. The results revealed that tuber crops-based farming system produced 3787.3 kg of rice equivalent yield, gross returns of Rs 75745 and net returns of Rs 46305/0.4 ha. Whereas, rice alone produced 1120 kg of rice and net returns of Rs 11300/0.4 ha (Table 16). Farming system involving tuber crops generated 46 man-days additional employment. Further, the employment was spread throughout the year.

Photo 83. Elephant foot yam crop at Barkigorang village, Ranchi district of Jharkhand

Photo 84. Vanaraja breed given to tribal beneficiaries

Photo 85. Khaki Campbell ducks given to tribal beneficiaries

Photo 86. Feeding cassava leaves and tubers to pig at Barkigorang village, Ranchi district of Jharkhand

Table 15. Integrated farming system components yield and economics (0.4 ha) Barkigorang, Ranchi, Jharkhand

Sl. No.	Crop/animal	Area (ha)	Yield (kg)	Rice equivalent yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	Employment generation (Man-days)
1	Rice	0.20	594	594	11880	5600	6280	46
2	Maize	0.02	33	24.8	495	250	245	2
3	Black gram	0.02	19	47.5	950	380	570	3
4	Sweet potato	0.02	298	149	2980	880	2100	4
5	Yam bean	0.04	546	409.5	8190	1500	6690	8
6	Greater yam	0.02	305	305	6100	1900	4200	7
7	Colocasia	0.02	239	239	4780	1800	2980	6
8	Elephant foot yam	0.02	297	297	5940	1900	4040	6
9	Cassava	0.01	146	73	1460	650	810	3
10	Vegetable (*Amaranthus*, Bhendi, bitter gourd, ridge gourd etc.)	0.03	503	503	10060	5000	5060	32
11	Backyard poultry & duckery	10 + 10 (Nos.)	43	258	5160	2000	3160	10
		Eggs	717	107.5	2150	480	1670	4
12	Pig	2 (Nos.)	104	780	15600	7100	8500	7
	Total	**0.4**	**3844**	**3787.3**	**75745**	**29440**	**46305**	**138**

*Sale price of rice Rs 20/kg, maize Rs 15/kg, black gram Rs 50/kg, sweet potato Rs 10/kg, yam bean Rs 15/kg, greater yam Rs 20/kg, colocasia Rs 20/kg, elephant foot yam Rs 20/kg, cassava Rs 10/kg, vegetables Rs 20/kg, poultry and duck meat Rs 120/kg, egg Rs 3/egg and pig meat Rs 150/kg.

Table 16. Check/Control at Barkigorang, Ranchi, Jharkhand

Sl. No.	Crop/animal	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	Employment generation (Man-days)
1	Rice	0.4	1120	22400	11100	11300	92

*Sale price of rice Rs 20/kg

8.5. Brief on demonstrations (2016-17)

During the year 2016-17, 145 tribal farm families were adopted and conducted tuber crops-based farming system(0.4 ha model) demonstration in each farmers fields in Odisha and Jharkhand (Photo 87, 88 and 89). In Jharkhand, Burhakocha village under Ranchi district was selected. Kenjagudaand Nuagudavillages in Kandhamal and Koraput districts of Odisha, respectively were selected. In Burhakocha, 57 beneficiaries and in Kenjaguda, 49 tribal families were selected. In Nuagada, 39 tribal families were selected. The quality planting materials of elephant foot yam (Gajendra) 3000 kg, greater yam (Orissa Elite) 1000 kg, yam bean (RM-1) 75 kg, cassava (Sree Jaya and Sree Vijaya) 5000 stems and sweet potato (Kishan, Bhu Sona and Bhu Krishna) 1.0 lakh vine cuttings were distributed to the tribal farmers. The demonstrations were monitored by regularly visiting the fields. Elephant foot yam var. Gajendra is susceptible to collar rot and leaf blight. Hence, farmers were advised to spray sixer or saaf 1.5 g/litre of water at 60 and 90 days after planting as a prophylactic measure. Sex pheromone traps were installed where sweet potato weevil infestation is severe.The average yield and economics of various components of tuber crops based integrated farming system were given in the Table 17.

Table 17. Integrated farming system components yield and economics (0.4 ha)

Crops/Other components	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C ratio	Employment generation (Man-days)
Rice	0.2	615	15375	7800	7575	1.97	52
Ragi	0.04	62	1240	560	680	2.21	6
Greater yam+maize	0.02	415+52	7005	2900	4105	2.42	10
Elephant foot yam	0.03	640	9600	3900	5700	2.46	12
Sweet potato	0.04	515	5150	2100	3050	2.45	10
Yam bean	0.06	945	14175	4150	10025	3.42	16
Cassava	0.01	155	1550	500	1050	3.10	5
Total	**0.4**	**3399**	**54095**	**21910**	**32185**	**2.58**	**111**

*Sale price of rice Rs 25/kg, ragi Rs 20/kg, sweet potato Rs 10/kg, yam bean Rs 15/kg, greater yam Rs 15/kg, elephant foot yam Rs 15/kg and cassava Rs 10/kg.

Table 18. Average yield and economics of check/control

Sl. No.	Crop/animal	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	Employment generation (Man-days)
1	Rice	0.4	1050	26250	15100	12800	91

*Sale price of rice Rs 25/kg

Prior to the interventions, the net income of the rice farmer was Rs 32000/ha with B:C ratio of 1.74 (Table 18). The employment generation was 228 man-days/ha. After intervention of 0.4 ha farming system involving tuber crops model, gross and net income of the farmer was Rs 135238 and Rs 80463/ha, respectively with B:C ratio of 2.58 (Table 19). The employment generation was 278 man-days/ha. Farming system involving tuber crops (0.4 ha model) generated additional 50 man-days/ha over before intervention (Table 19).

Table 19. Yield and economics prior to the intervention and after the intervention

Particulars	Prior to intervention	After intervention
Gross income (Rs/ha)	65625	135238
Net income (Rs/ha)	32000	80463
B:C Ratio	1.74	2.58
Employment generation (Man-days/ha)	228	278
Distribution of labours (no. months)	6	12

Photo 87. Greater yam+maize intercropping in Nuaguda village Koraput district of Odisha

Photo 88. Tuber crops cultivation at Kenjaguda village, Kandhamal district of Odisha

Photo 89. Tuber crops demonstration at Burhakocha village, Ranchi district of Jharkhand

8.6. Brief on demonstrations (2017-18)

During the year 2017-18 two tribal villages were selected one each from Odisha and Jharkhand states. Dadrisahi village in Chakapad block, Kandhamal district, Odisha and Burahkocha village in Angara block, Ranchi district, Jharkhand were selected. In Dadrisahi village 24 tribal households and in Burahkocha village 57 tribal households were adopted for conducting tuber crops demonstrations. Sweet potato (Kishan, Bhu Sona and Bhu Krishna) 50,000 vine cuttings, cassava (Sree Jaya and Sree Vijaya) 3000 stems, yam bean (RM-1) 52.5 kg, vegetable seeds (brinjal, tomato etc.) 5.6 kg and greater yam (Orissa Elite) 3000 kg were distributed to the farmers. A solar pumpset was installed in Burahkocha (village), Angara (block), Ranchi (district), Jharkhand for irrigating the crops during dry spells and *rabi* and summer seasons. The demonstrations were monitored by regular visiting the fields. Sex pheromone traps were installed where sweet potato weevil infestation is severe.The average yield of various components from all the locations of integrated farming system was given in the Table 20 on per ha basis (Photo 90, 91, 92 and 93).

Table 20. Integrated farming system components yield and economics (0.4 ha)

Crops/Other components	Area (ha)	Yield (kg/ha)	Gross Income (Rs/ha)	Cost of cultivation (Rs/ha)	Net income (Rs/ha)	B:C ratio	Employment generation (Man-days/ 0.4 ha)
Rice	0.2	3205	96150	44200	51950	2.18	52
Ragi	0.04	1300	26000	9400	16600	2.77	6
Redgram	0.02	1600	80000	23500	56500	3.40	5
Sweet potato	0.04	12675	126750	43800	82950	2.89	10
Yam bean	0.08	15625	234370	69200	165170	3.39	14
Cassava	0.01	12400	124000	46400	77600	2.67	5
Vegetables (brinjal, tomato, ridge gourd, bitter gourd and Raikya beans)	0.01	18200	364000	155000	209000	2.35	20
Total	**0.4**	**9286**	**150180**	**55930**	**94250**	**2.69**	**112**

*Sale price of rice Rs 30/kg, ragi Rs 20/kg, red gram Rs 50/kg, sweet potato Rs 10/kg, yam bean Rs 15/kg, cassava Rs 10/kg and vegetables Rs 20/kg.

Prior to the interventions, the major crops grown were rice, ragi, maize and vegetables like brinjal, tomato and bean. The average yield was 4350 kg/ha and the gross income of the farmer was Rs 90750/ha and B:C ratio of 1.96 (Table 21). The employment generation was 200 man-days/ha. After intervention of 0.4 ha farming system involving tuber crops model, gross income of the farmer was Rs 150180/ha with B:C ratio of 2.69. The employment generation was 280 man-days/ha. Farming system involving tuber crops (0.4 ha model) generated additional 80 man-days/ha over before intervention (Table 21).

Table 21. Yield and economics of prior to the intervention and after the intervention

Particulars	Prior to intervention	After intervention
Gross income (Rs/ha)	90750	150180
Net income (Rs/ha)	47950	94250
B:C Ratio	1.96	2.69
Employment generation (man-days/ha)	200	280
Distribution of labours (no. months)	6	12

Photo 90. Yam bean harvest at Dadrisahi village, Kandhamal district of Odisha

Photo 91. Sweet potato harvest at Dadrisahi village, Kandhamal district of Odisha

Photo 92. Tuber crops cultivation at Burahkocha village, Ranchi district of Jharkahand

Photo 93. Solar pumpset at Burahkocha village, Ranchi district of Jharkhand

8.7. Brief on demonstrations (2018-19)

Gajapati district of Odisha is covered by hills and plateau lands. Maize is the major crop in this district. During the year 2018-19, 200 tribal farmers were selected from Mohana Block (Dimirijholi, Jubagaon, Andiragada and Anangadongra villages) and R.Udayagiri Block (Kharipada, Sinisingh, Patrabasa Nayak Sahi and Lubursingh villages) of Gajapati district for demonstrating tuber crops-based farming system (0.2 ha model). In this 0.2 ha model the area of various crop components was as follows: maize 0.08 ha, greater yam+maize intercropping 0.03 ha, sweet potato 0.04 ha, yam bean 0.04 ha, cassava 0.01 ha. All the above crop components were sown/ planted during *kharif* season. Vegetables were grown in *rabi* season in 0.01 ha. Backyard poultry 10 Vanaraja birds (45 days old) were also given to each farmer/ demonstration. The tuber crops planting materials like sweet potato (Bhu Sona, Bhu Krishna and Kishan) 200000 vine cuttings, cassava (Sree Jaya and Sree Vijaya) 5000 stems, greater yam (Orissa Elite) tubers 3000 kg, maize 10 kg, red gram 10 kg and yam bean (RM-1) seeds 100 kg were distributed to 200 nos. of tribal farmers. Vegetable kits (each kit contains *Amaranthus*, bhendi, chilli, onion, cowpea, French bean, *Dolichos* and bottle gourd seeds) 300 Nos. and 2000 poultry birds (Vanaraja) were also distributed to tribal farmers to supplement the farm income. Farmers also contributed maize seeds. Demonstrations were monitored regularly to address the problems faced by the tribal farmers. Sex pheromone traps were installed where sweet potato weevil infestation is severe. The data on cropping pattern and socio- economic conditions of the farmers before (Table 22) and after interventions (Table 23) was collected and presented below.

Table 22. Crop yield and economics prior to intervention

Crops/Other components	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C ratio	Employment generation (Man-days)
Maize	0.2	655	9825	5100	4725	1.93	47

Table 23. Component-wise yield and economics of tuber crops-based farming system (0.2 ha model)

Crops/Other components	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C ratio	Employment generation (Man-days)
Maize	0.08	318	4770	2200	2570	2.17	15
Greater yam+ maize	0.03	599 + 113	8985 + 1695	3100 + 200	5885 + 1495	3.24	19
Sweet potato	0.04	502	5020	1800	3220	2.79	6
Yam bean	0.04	543	8145	1600	6545	5.09	10
Cassava	0.01	125	1250	500	750	2.50	3
Vegetable (*rabi*)	0.01	200	4000	1525	2475	2.62	12
Backyard poultry	10 Nos.	22 + 180 Nos. eggs	2640 + 900	600 + 300	2040 + 600	4.40	8
Total	**0.2**	**-**	**37405**	**11825**	**25580**	**3.16**	**73**

*Sale price of maize Rs 15/kg, greater yam Rs 15/kg, sweet potato Rs 10/kg, yam bean Rs 15/kg, cassava Rs 10/kg, vegetables Rs 20/kg, poultry meat Rs 120/kg and egg Rs 5/egg.

In tuber crops-based farming system demonstrations, the average yield of maize was 3975 kg/ha, greater yam+maize intercropping greater yam and maize yield were 19967 and 3767 kg/ha, respectively, sweet potato tuber yield was 12550 kg/ha, yam bean tuber yield was 13575 kg/ha, cassava tuber yield was 12500 kg/ha and vegetables yield were 20000 kg/ha (Table 23) (Photo 94, 95, 96, 97, 98 and 99). The tuber crops-based farming system (0.2 ha model) recorded average crop yield of 2400 kg, and meat yield of 22 kg with 180 eggs from the poultry birds. Prior to the interventions, the gross income of the farmer was Rs 49125/ha with B:C ratio of 1.93 (Table 24). The employment generation was 235 man-days/ha. After intervention of 0.2 ha farming system involving tuber crops model, gross income of the farmer was Rs 187025/ha with B:C ratio of 3.16 (Table 24). The employment generation was 365 man-days/ha. Farming system involving tuber crops (0.2 ha model) generated additional 130 man-days/ha over before intervention. The tuber crops-based farming system can be managed by the own family labourers, as the employment was distributed through-out the year.

Table 24. Economics on per-hectare basis before and after intervention of tuber crops-based farming system (0.2 ha model)

Intervention	components	Gross Income (Rs/ha)	Cost of cultivation (Rs/ha)	Net income (Rs/ha)	B:C ratio	Employment generation (Man-days)	Distribution of labours (No. months)
Before	Maize	49125	25500	23625	1.93	235	6
After	Tuber crops based farming system	187025	59125	127900	3.16	365	12

Photo 94. Tuber crops cultivation in Anangadongra village of Gajapati district of Odisha

Photo 95. Backyard poultry at Dimirijholi village of Gajapati district of Odisha

Photo 96. Bottle gourd cultivation in Jubagaon village of Gajapati district of Odisha

Photo 97. Yam bean harvest at Andiragada villageof Gajapati district of Odisha

Photo 98. Onion cultivation in Lubursingh village of Gajapati district of Odisha

Photo 99. Sweet potato harvest at Kharipada village of Gajapati district of Odisha

8.8. Brief on demonstrations (2019-20)

During the year 2019-20, 20 tribal households were adopted from Budukakhol, Bandhakhamana and Kharijhola villages of Chakapada (Block), Kandhamal (District), Odisha and 15 tribal households were adopted from Andragada, Jubagaon, Ateli and Chandragiri villages of Mohana (Block), Gajapati (District), Odisha for demonstrating tuber crops-based farming system (0.2 ha model). The quality planting materials of elephant foot yam (Gajendra) 2000 kg, greater yam (Orissa Elite) 2000 kg, *Colocasia* (Muktakeshi) 200 kg, yam bean (RM-1) 20 kg, cassava (Sree Jaya and Sree Vijaya) 3000 stems, sweet potato (Bhu Sona, Bhu Krishna and Kishan) 1.5 lakh vine cuttings, maize 20 kg, red gram 10 kg and vegetable seeds kits (*Amaranthus*, bhendi, chilli, onion, cowpea, French bean, *Dolichos* and bottle gourd seeds) 60 nos. were distributed to the tribal farmers. Along with crop component, animal component poultry bird Vanaraja 800 nos. was also distributed to the tribal farmers.

In this intervention, tuber crops planting materials were provided to the farmers along with improved varieties of maize and vegetables. Each farmers field 0.2 ha model tuber crops-based farming system was demonstrated. The crop and other components are as follows: Maize (0.05 ha), greater yam+maize (0.03 ha), elephant foot yam (0.02 ha), taro (0.01 ha), sweet potato+red gram (0.04 ha), yam bean (0.04 ha) and cassava (0.01 ha). Planting of the above seeds were carried out during *kharif* season. Vegetables (*Amaranthus*, bhendi, chilli, onion, cowpea, French bean, *Dolichos* and bottle gourd seeds) 0.01 ha cultivated during *rabi* season. Backyard poultry 20 nos. (45 days old) was given to each household. The crop and animal components were monitored regularly by field visits (Photo 100, 101, 102, 103, 104 and 105). Elephant foot yam var. Gajendra is susceptible to collar rot and leaf blight. Hence, farmers were advised to spray sixer or saaf 1.5 g/litre of water at 60 and 90 days after planting as a prophylactic measure. Sex pheromone traps were installed where sweet potato weevil infestation is severe. The data on cropping pattern and socio-economic conditions of the farmers before (Table 25) and after interventions (Table 26) were collected and presented below.

Table 25. Crop yield and economics prior to intervention

Crops/Other components	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C ratio	Employment generation (Man-days)
Maize	0.2	705	10575	5100	5475	2.07	50

*Sale price of maize Rs 15/kg.

Table 26. Component-wise yield and economics of tuber crops-based farming system (0.2 ha

Crops/Other components	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C ratio	Employment generation (Man-days)
Maize	0.05	224	3360	1300	2060	2.58	8
Greater yam+ maize	0.03	585 + 126	8775 + 1890	3000 + 200	5775 + 1690	3.33	15
Elephant foot yam	0.02	526	7890	2700	5190	2.92	12
Taro	0.01	185	2775	950	1825	2.92	6
Sweet potato+red gram	0.04	490 + 30	4900 + 1200	2000	4100	3.05	8
Yam bean	0.04	558	8370	2100	6270	3.99	9
Cassava	0.01	162	2430	800	1630	3.04	5
Vegetable (*rabi*)	0.01	210	4200	1600	2600	2.62	8
Backyard poultry	20 Nos.	45+390 Nos. eggs	5400 + 1950	1200 + 600	4200 + 1350	4.08	12
Total	**0.2**	**3096+ 45+390 Nos. eggs**	**53140**	**16450**	**36690**	**3.23**	**82**

*Sale price of maize Rs 15/kg, greater yam Rs 15/kg, elephant foot yam Rs 15/kg, taro Rs 15/kg, sweet potato Rs 10/kg, yam bean Rs 15/kg, cassava Rs 15/kg, red gram Rs 40/kg, vegetables Rs 20/kg, poultry meat Rs 120/kg and egg Rs 5/egg.

Prior to the interventions, the gross income of the farmer was Rs 52875/ha with B:C ratio of 2.07 (Table 27). The employment generation was 250 man-days/ha. After intervention of 0.2 ha farming system involving tuber crops model, gross income of the farmer was Rs 265700/ha with B:C ratio of 3.23 (Table 27). The employment generation was 410 man-days/ha. Farming system involving tuber crops (0.2 ha model) generated additional 160 man-days/ha over before intervention (Table 27). Each tribal household produced sufficient tubers, maize, meat and eggs for house hold consumption (food and nutritional security) and surplus for selling (cash income).

Table 27. Economics on per-hectare basis before and after intervention of tuber crops-based farming system

Intervention	components	Gross Income (Rs/ha)	Cost of cultivation (Rs/ha)	Net income (Rs/ha)	B:C ratio	Employment generation (Man-days)	Distribution of labours (No. months)
Before	Maize	52875	25500	27375	2.07	250	6
After	Tuber crops-based farming system	265700	82250	183450	3.23	410	12

Photo 100. Cassava, sweet potato and yam bean cultivation at Andragada village in Gajapati district of Odisha

Photo 101. Sweet potato in tribal farmer's field at Jubagaon village in Gajapati district of Odisha

Photo 102. Yam bean harvest at Kharijola village in Kandhamal district of Odisha

Photo 103. Elephant foot yam harvest at Kharijola village in Kandhamal district of Odisha

Photo 104. Sweet potato harvest at Kharijola village in Kandhamal district of Odisha

Photo 105. Vanaraja chicks given to beneficiaries at Kharijola village in Kandhamal district of Odisha

8.9. Brief on demonstrations (2020-21)

During the year 2020-21, 47 tribal households were adopted from Phalsipadar village in Tikabali (Block), Bujulimendi, Budhapadara, Nediguda, Kantiadhia and Jharkedi villages in Chakapada (Block), Kandhamal (District) for demonstrating tuber crops-based farming system (0.4 ha model). Planting materials of sweet potato (Kishan, Bhu Sona, Bhu Krishna, Gouri and Sankar) 225000 vine cuttings, greater yam (Sree Nidhi and Orissa Elite) tubers 3000 kg, elephant foot yam (Gajendra) 3000 kg, *Colocasia*/taro (Muktakeshi and Telia) 500 kg, cassava (Sree Jaya and Sree Vijaya) 3000 stems, yam bean (RM-1) seeds 25 kg, maize seed 20 kg, red gram 10 kg, vegetable seed kits 125 nos. and back yard poultry birds (Vanaraja) 1000 nos. were distributed to the tribal farmers. Ninety-eight black Bengal goats were also distributed to the beneficiaries.

In this intervention, tuber crops planting materials were provided to the farmers along with improved varieties of rice, maize and vegetables. Each farmers field 0.4 ha model farming system involving tuber crops was demonstrated. The crop and other components are as follows: Rice (0.2 ha), greater yam+maize (0.03 ha), sweet potato+red gram (0.06 ha), yam bean (0.06 ha), elephant foot yam (0.02 ha), colocasia (0.02 ha) and cassava (0.01 ha). Planting of the above seeds were carried out during June-July. Vegetables (*Amaranthus*, bhendi, chilli, onion, cowpea, French bean, *Dolichos* and bottle gourd seeds) 0.01 ha were cultivated during *rabi* season. Backyard poultry 20 nos. (45 days old) and 2 female black Bengal goats (Doe) were given to each household. Two black Bengal bucks (male goats) were given to the 2 SHG group to improve the goat's progeny. The demonstrations were monitored by regular visiting the fields (Photo 106, 107, 108 and 109). Elephant foot yam var. Gajendra is susceptible to collar rot and leaf blight. Hence farmers were advised to spray sixer or saaf 1.5 g/litre of water at 60 and 90 days after planting as a prophylactic measure. Similarly, colocasia var. Telia is also susceptible to leaf blight, hence farmers were suggested to spray sixer or saaf 1.5 g/litre of water at 60 and 90 days after planting as a prophylactic measure. Sex pheromone traps were installed where sweet potato weevil infestation is severe. Farmers were also advised to do earthing up in sweet potato field at 60 and 90 days after planting to prevent weevil multiplication. The data on cropping pattern and socio- economic conditions of the farmers before (Table 28) and after interventions (Table 29) was collected and presented below.

Table 28. Crop yield and economics prior to intervention

Crops/Other components	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C ratio	Employment generation (Man-days)
Rice	0.4	1375	34375	18000	16375	1.91	94

*Sale price of rice Rs 25/kg.

Table 29. Component-wise yield and economics of tuber crops-based farming system (0.4 ha model)

Crops/Other components	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C ratio	Employment generation (Man-days)
Rice	0.2	710	17750	8000	9750	2.22	52
Greater yam+ maize	0.03	612+125	11055	4750	6305	2.33	24
Sweet potato+red gram	0.06	765+ 62	7650+ 2480	3600	6530	2.81	22
Yam bean	0.06	820	12300	4100	8200	3.00	24
Elephant foot yam	0.02	505	7575	3200	4375	2.37	20
Colocasia/taro	0.02	425	6375	2375	4000	2.68	14
Cassava	0.01	160	1600	650	950	2.46	4
Vegetable (*rabi*)	0.01	210	4200	1850	2350	2.27	12
Backyard poultry	20 Nos.	45+388 Nos. eggs	6750+ 1940	2000	6690	4.35	6
Goat	2 Nos.	32	19200	9000	10200	2.13	8
Total	**0.4**	**4394 + 77+388 Nos. eggs**	**98875**	**39525**	**59350**	**2.50**	**186**

*Sale price of rice Rs 25/kg, maize Rs 15/kg, greater yam Rs 15/kg, sweet potato Rs 10/kg, yam bean Rs 15/kg, EFY Rs 15/kg, colocasia Rs 15/kg, cassava Rs 10/kg, red gram Rs 40/kg, vegetables Rs 20/kg, poultry meat Rs 150/kg, egg Rs 5/egg and goat meat Rs 600/kg.

Prior to the interventions, the gross income of the farmer was Rs 85938/ha with B:C ratio of 1.91 (Table 30). The employment generation was 288 man-days/ha. After intervention of 0.4 ha model of tuber crops-based farming system, gross income of the farmer was Rs 247188/ha with B:C ratio of 2.50. The employment generation was 465 man-days/ha. Tuber crops-based farming system (0.4 ha model) generated additional 177 man-days/ha over before intervention (Table 30). Each tribal household produced sufficient tubers, rice, ragi, maize etc. for house hold consumption (food and nutritional security) and surplus for selling (cash income). Sufficient vegetables, meat and egg were available for household consumption and selling.

Table 30. Economics on per-hectare basis before and after intervention of tuber crops-based farming system

Intervention	components	Gross Income (Rs/ha)	Cost of cultivation (Rs/ha)	Net income (Rs/ha)	B:C ratio	Employment generation (Man-days)
Before	Rice	85938	45000	40938	1.91	288
After	Tuber crops-based farming system	247188	98813	148375	2.50	465

Photo 106. Farming system demonstration at Bujulimendi village in Kandhamal district of Odisha

Photo 107. Farming system demonstration at Nediguda village in Kandhamal district of Odisha

Photo 108. Black Bengal goat distribution to tribal farmers of Kandhamal district of Odisha

Photo 109. Black Bengal goat distribution to tribal farmers of Kandhamal district of Odisha

8.10. Brief on demonstrations (2021-22)

During the year 2021-22, 523 tribal farmers were adopted from Koraput (21 tribal farmers from Almaguda and Missingguda villages in Semiliguda block and 41 tribal farmers from Khirajhola village in Potangi block), Kandhamal (70 tribal farmers from Madaguda, Kharimunda, Landabali, Pabangaon, Jharihgati and Bandagpada villages in Kotagarh block, 82 tribal farmers from Betabadi, Badabandha, Saradhapur, Dadang and Sunagaon villages in Thumidibandha block, 50 tribal farmers from Sripalla, Kedaruha, Nuapadar, Bhrungjodi, Rabingia, Kutiguda, Dakapada, Jangipada and Tetkapadar villages in Phiringia block and 25 tribal farmers from Bahadasahi, Paikachira and Gadapadara villages in Chakapada block) and Rayagada (109 tribal farmers from Karnaguda, Birisiguda, Ranibondho, Khumbaribadi and Marthagada villages of Bissam Cuttack block and 125 tribal farmers from Sakata, Merkamandili, Kesarpadi, Panchukudi, Sharamhi and Kaliaripeta villages of Muniguda block) districts in Odisha. Quality planting materials of sweet potato (Bhu Sona, Bhu

Krishna, Kishan and Gouri) 18.12 lakhs vine cuttings, greater yam (Sree Nidhi, Sree Neelima and Orissa Elite) 11,800 kg, elephant foot yam (Gajendra) 4,500 kg, *Colocasia*/taro (Muktakeshi and Telia) 700 kg, yam bean (RM-1) seeds 100 kg, cassava (Sree Jaya, Sree Vijaya and Sree Visakham) 6,000 stems, maize seed 20 kg and red gram 10 kg, were distributed to the tribal farmers. To supplement nutrition, 600 nos. vegetable seed kits (contain *Amaranthus*, bhendi, chilli, cowpea, French bean, tomato, palak and *Dolichos* seeds) were distributed to the tribal farmers. Further, 870 nos. of Kalinga Brown poultry chicks were distributed to the tribal farmers in Semiliguda and Pottangi blocks of Koraput district of Odisha, and Chakapada block of Kandhamal district of Odisha. A total of 523 nos. each of spade, crowbar, pickaxe, prong, sickle and sprayers were distributed to the tribal farmers to reduce the drudgery of field operations and to manage pest diseases timely and effectively.

Crop diversification with tuber crops were demonstrated in Kotagarh, Thumidibandha and Phiringia blocks of Kandhamal district and Bissam Cuttack and Muniguda blocks of Rayagada district. Tuber crops-based farming system (0.4 ha model) was demonstrated in Semiliguda and Potangi blocks of Koraput district, and Chakapada block of Kandhamal district. The demonstrations were monitored by regular visiting the fields (Photo 110, 111, 112 and 113). Elephant foot yam var. Gajendra is susceptible to collar rot and leaf blight. Hence, farmers were advised to spray sixer or saaf 1.5 g/litre of water at 60 and 90 days after planting as a prophylactic measure. Similarly, colocasia var. Telia is also susceptible to leaf blight, hence farmers were suggested to spray sixer or saaf 1.5 g/litre of water at 60 and 90 days after planting as a prophylactic measure. Sex pheromone traps were installed where sweet potato weevil infestation is severe. Farmers were also advised to do earthing up in sweet potato field at 60 and 90 days after planting to prevent weevil multiplication.

Under crop diversification, tuber crops demonstrations in tribal farmers field resulted in the average yield of sweet potato 14.2 t/ha, taro 13.5 t/ha, greater yam 26.2 t/ha, elephant foot yam 25 t/ha, yam bean 20.5 t/ha and cassava 16.5 t/ha (Table 31). Cost of calculation, gross and net returns also calculated and presented in Table 26. Maximum benefit cost ratio was observed in yam bean cultivation (3.45).

Table 31. Crop diversification with tuber crops and their performance in tribal farmers' fields

Crop	Average tuber yield (t/ha)	Gross return (Rs/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	Benefit: cost ratio
Sweet potato cuttings (Bhu Sona and Bhu Krishna)	14.2	142000	54800	87200	2.59
Taro (Muktakeshi and Telia)	13.5	202500	96000	106500	2.11
Greater yam (Orissa Elite and Sree Nidhi)	26.2	393000	165000	228000	2.38
Elephant foot yam (Gajendra)	25.0	375000	152000	223000	2.47
Yam bean (RM-1)	20.5	307500	89200	218300	3.45
Cassava (Sree Jaya and Sree Vijaya)	16.5	165000	56400	108600	2.93

*Sale price of sweet potato Rs 10/kg, taro Rs 15/kg, greater yam Rs 15/kg, elephant foot yam Rs 15/kg, yam bean Rs 15/kg and cassava Rs 10/kg.

Tuber crops-based farming system (0.4 ha model) demonstrated in Semiliguda and Potangi blocks of Koraput district, and Chakapada block of Kandhamal district resulted in higher farm yield and income to the tribal farmers.Crop-wise area, yield and income of the tuber crops-based farming system were presented in Table 32. Among tuber crops, higher B:C ratio was observed with yam bean cultivation (3.02). However, animal component, backyard poultry resulted in maximum B;C ratio of 4.13.

Table 32. Component-wise yield and economics of tuber crops-based farming system (0.4 ha model)

Crops/Other components	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C ratio	Employment generation (Man-days)
Rice	0.2	728	18200	8000	10200	2.28	53
Greater yam+ maize	0.03	618 + 98	10740	4250	6490	2.53	22
Sweet potato	0.06	840	8400	3100	5300	2.71	18
Yam bean	0.06	825	12375	4100	8275	3.02	24
Elephant foot yam	0.02	512	7680	3200	4480	2.40	20
Colocasia/taro	0.02	412	6180	2300	3880	2.69	13
Cassava	0.01	165	1650	650	1000	2.54	4
Vegetable (*rabi*)	0.01	220	4400	1900	2500	2.32	12
Backyard poultry	20 Nos.	43 + 360 Nos. eggs	6450 + 1800	2000	6250	4.13	6
Goat	2 Nos.	32	19200	9000	10200	2.13	8
Total	**0.4**	**4418 + 43 + 360 Nos. eggs**	**77875**	**29500**	**48375**	**2.64**	**172**

*Sale price of rice Rs 25/kg, maize Rs 15/kg, greater yam Rs 15/kg, sweet potato Rs 10/kg, yam bean Rs 15/kg, EFY Rs 15/kg, colocasia Rs 15/kg, cassava Rs 10/kg, red gram Rs 40/kg, vegetables Rs 20/kg, poultry meat Rs 150/kg and egg Rs 5/egg.

The data on cropping pattern and socio- economic conditions of the farmers before and after interventions was collected. Prior to the interventions, the gross income of the farmer was Rs 86000/ha with B:C ratio of 1.91 (Table 33). The employment generation was 285 man-days/ha. After intervention of 0.4 ha model of tuber crops-based farming system, gross income of the farmer was Rs 194688/ha with B:C ratio of 2.64. The employment generation was 430 man-days/ha. Tuber crops-based farming system (0.4 ha model) generated additional 145 man-days/ha over before

intervention (Table 33). Each tribal household produced sufficient tubers, rice, maize etc. for house hold consumption (food and nutritional security) and surplus for selling (cash income). Sufficient vegetables, meat and egg were available for household consumption and selling.

Table 33. Economics on per-hectare basis before and after intervention of tuber crops-based farming system

Intervention	components	Gross Income (Rs/ha)	Cost of cultivation (Rs/ha)	Net income (Rs/ha)	B:C ratio	Employment generation (Man-days)
Before	Rice	86000	45000	46000	1.91	285
After	Tuber crops-based farming system	194688	73750	120938	2.64	430

Photo 110. Sweet potato planting materials distributed to Dongria tribals in Bissam Cuttack block of Rayagada district of Odisha

Photo 111. Bhu Krishna variety of sweet potato cultivation in Khirajola village in Koraput district

Photo 112. Greater yam+maize intercropping in Semiliguda block in Koraput district of Odisha

Photo 113. Farming system demonstration in Badahsahi village in Kandhamal district of Odisha

9. VALUE ADDITION OF TUBER CROPS

Generally, tubers are consumed directly by boiling and baking, and preparations of curries. Shelf-life of some of the tuber crops are very few days. Hence, the availability of tuber crops is in specific period only. Further, farmers also fetching lower price due to market glut during harvesting. Cassava tubers shelf-life is 2 days and sweet potato shelf-life is 20-30 days only. Within this period, these tubers are to be consumed. Minimal processing and value addition will increase the availability of these tubers for more periods. Value addition of tuber crops to the acceptable food preference form will increases income and the demand for the tuber crops (Figure 1).

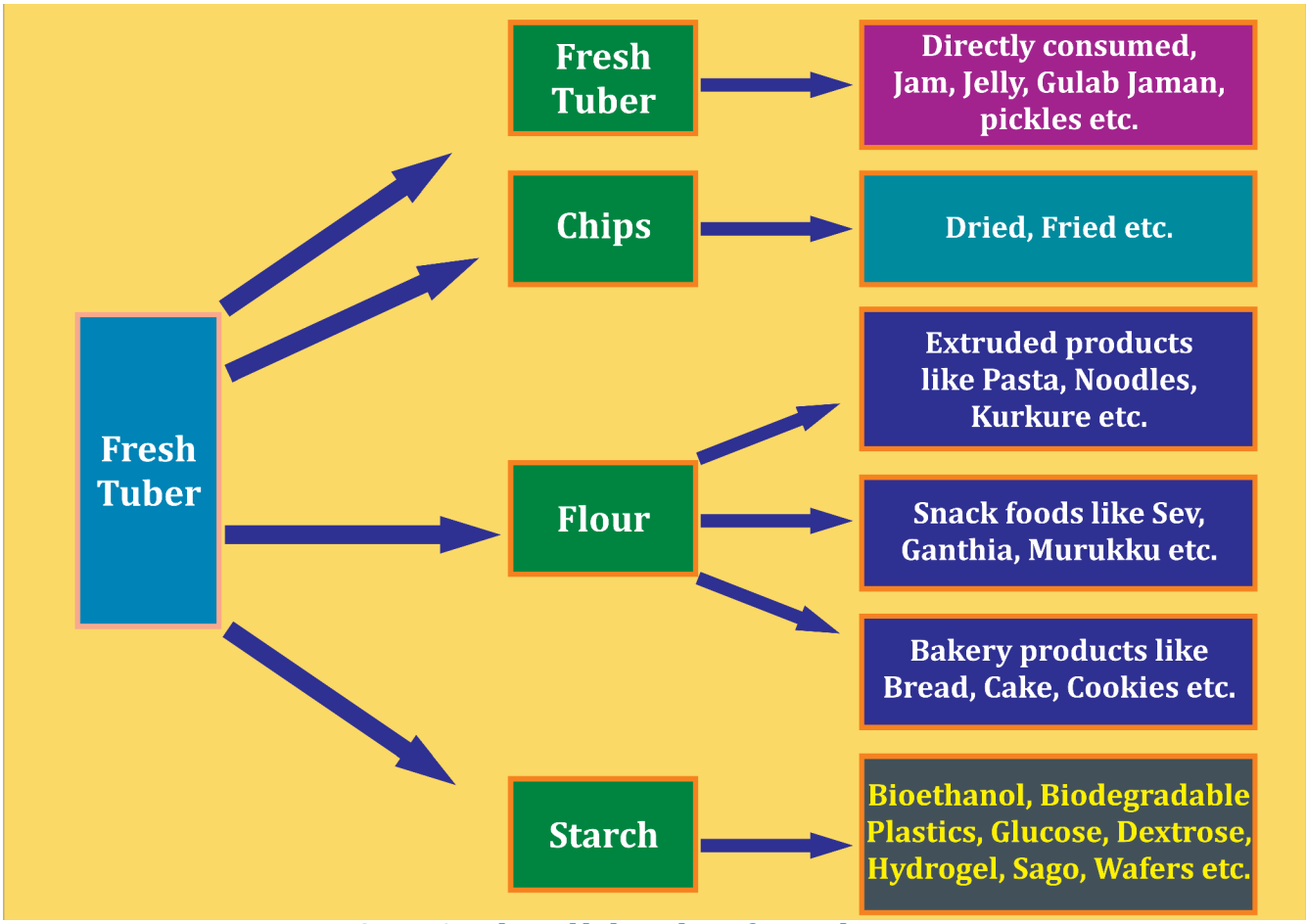


Figure 1. Value added products from tuber crops

9.1. Minimal processing

Dried chips

Cassava and sweet potato fresh tubers are sliced/chipped after washing. The slices/chips are sundried or tunnel dried for 48-72 hours and then packed in air tight containers. The dried slices/chips can be stored up to one year.

Par-boiled chips

Cassava and sweet potato fresh tubers are sliced/chipped after washing. The slices/chips are put in boiling water and cooked for 5-10 minutes depending up on the thickness of slices/chips.

The cooked slices/chips are sundried or tunnel dried for 48-72 hours and then packed in air tight containers. The dried par-boiled slices/chips can be stored up to one year.

9.2. Value added products from cassava

Fried cassava chips

Fresh cassava tubers are washed and peeled. The tubers are sliced/chipped 1.5-2.0 mm thickness. Then the slices/chips are soaked in acetic acid-brine solution for 1 h, parboiling for 5 minutes followed by surface drying and deep frying in oil.

Cassava pasta

Besides, pasta getting wide popularity among the young Indians and in the metros as a convenient food, transformation to new health and wellness foods is essential to add value to cassava and sustain their cultivation of in India.

Cassava pappad

Papads are prepared from cassava flour by adding fibre sources like wheat bran, oat meal, rice bran and cassava fibrous residue. The fibre sources are added to gelatinized cassava slurry and mixed thoroughly. The spicy condiments are also added and spread on plastic sheets which are then dried in the sun for 36 h. The papads are peeled off from the sheets and packed. The deep fried products have soft and crisp texture.

Fried snack foods from cassava

The cost of making value added snack foods from cassava could be considerably reduced, if wet cassava paste is used instead of cassava flour (Photo 114). Such an innovation was made in making a highly acceptable crisp snack food viz., chitchore from cassava. The wet cassava tuber paste is mixed with ingredients like maida, cheese, salt, sugar, baking powder and white pepper. The dough after proofing for 1 h is spread into sheets and cut into small discs of 1 cm diameter.

Cassava *pakkavada:*

This is a hot snack food having good texture and taste made out of cassava flour. The other ingredients include maida, bengal gram flour, salt, chilli powder, asafoetida, baking soda and oil. The ingredients are thoroughly mixed and made into dough with hot water (50^0 C), proofed for 1 h and then extruded through hand extruder having flat rectangular holes, into hot oil.

Cassava sweet fries:

This is a sweet snack food made out of cassava flour, maida, baking soda and oil. The ingredients are mixed well and made into dough with hot water (50^0 C). The dough after proofing for 1 h is hand extruded through die having round holes, into hot oil. The fried product is then coated with sugar by dipping for a few minutes in sugar syrup having thick consistency.

Cassava nutria-chips:

This is a high protein snack food made out of cassava flour by mixing with other ingredients like maida, groundnut paste, egg, salt, sugar, sesame, coconut milk, baking soda and oil. After mixing the ingredients, hot water is added and mixed to form smooth dough. The dough after proofing is

made into small balls which are then spread into sheets of 2 mm thickness. This is then cut into diamond shape using a sharp knife and deep fried in oil.

Cassava crisps:

This is a soft and good textured crispy snack food made from cassava flour, maida, rice flour, bengal gram flour, salt, baking soda, turmeric powder and oil. The dough made with hot water is proofed for 1 h and then extruded through the small pore size die having round holes. The deep fried material is mixed with fried nuts, curry leaves etc. before packing.

Photo 114. Snack food from cassava

9.3. Value added products from sweet potato

Sweet potato is a very important tuber crop in Odisha. It is cultivated in an area of 43460 ha with the production of 410100 tonnes (NHB, 2013). It is cultivated almost in all the tribal dominated districts. At present it is consumed after boiling or baking as secondary staple. It is also used as vegetable in 'Curry' and 'Dalmah' preparation. These roots are rich in starch, sugars, vitamins and minerals. Some sweet potato varieties contain coloured pigments anthocyanin, β-carotene and unidentified flavonoids. These pigments are regarded as beneficial antioxidants having several physiological attributes such as anti-oxidation, anticancer and protection against liver injury. Recently World Health Food Organization (WHFO) labelled sweet potato as an "antidiabetic" food. Some studies conducted in animals showed that sweet potato diet helped to stabilize blood sugar levels and lowered insulin resistance. The ICAR-Central Tuber Crops Research Institute, Regional Centre, Bhubaneswar has released two nutritionally important sweet potato varieties *i.e.* Bhu Sona (orange fleshed β-carotene rich) and Bhu Krishna (purple fleshed anthocyanin rich) (Photo 115a and 115b). Sweet potato is rich source of dietary fibres. The importance of dietary fibre in food is well recognized. Dietary fibre reduces serum cholesterol, prevents colon cancers, and maintains good intestinal health as well as prophylactic action on cardiovascular diseases, diabetes and obesity.

Though the Regional Centre of ICAR-CTCRI, Bhubaneswar has developed many value added technologies in sweet potato, no value-added product is available in the market. Yet, the Regional

Centre of ICAR-CTCRI, Bhubaneswar has demonstrated some of the simple value-added products development to the tribal farmers and entrepreneuring youth through TSP.

(115a) Orange fleshed sweet potato (Var. Bhu Sona)

(115b) Purple fleshed sweet potato (Var. Bhu Krishna)

Photo 115a and 115b. Biofortified varieties of sweet potato

Sweet potato fried chips

Fried sweet potato chips presently not available in Indian market. Excellent quality fried chips can be made from sweet potato tubers, by subjecting to mild acid treatment. This can prevent the discoloration of sweet potato slices, with the result that light yellow crispy chips can be obtained, having soft mouthfeel and good texture. About 4 months old tubers are chosen for making chips. After slicing into round pieces with thickness of about 2 mm, soaked for 15 minutes in 0.5% citric acid-0.5% brine (salt) solution. After soaking, wash with clean water and keep slices in shade drying for 30 minutes to remove surface moisture. Fry the slices at 150°C for 5 minutes, mix the seasonings and pack it.

Fried snacks from sweet potato flour

Sweet potato flour is gluten free and having low protein content. Hence fortification is done by mixing with nutritionally superior flours to enhance the nutritional and textural value of food products. Various fried snack foods have been developed. They are sweet potato nutri sticks, crisps etc (Photo 116).

Photo 116. Snack food from sweet potato

Chappati, puri and parota from sweet potato flour

Chappati, puri and parota can be prepared from sweet potato flour. As sweet potato flour is devoid of gluten, some binding agent should be added for the preparation of the above products.

Sweet potato cake

Anthocyanin rich, gluten free cake could be made from purple fleshed sweet potato (variety Bhu Krishna) flour, sugar, eggs, butter and baking powder. The preparation method includes steps like; beating of butter/vanspati ghee, add ground sugar and make the cream, separately beat the eggs and add into the cream. Add sieved sweet potato flour and baking powder into the cream-egg mixture, thorough mixing of batter, pour batter into previously greased baking pan. Bake at 160° C for 25-30 minutes; cool the cake at room temperature. The prepared cake is healthy for consumers (Photo 117a).

Sweet potato pasta

Use of purple fleshed sweet potato flour gives dark purple coloured pasta which had low starch digestibility and high resistant starch content besides high anthocynin and protein content (Photo 117b). This nutri pasta without any preservative could be introduced to mid-day meal programme (MDMP) of school children. The preparation steps include: mixing of ingredients (sweet potato flour, whole wheat flour, semolina and water) for 15 minutes. Transfer and knead in pasta machine for 5 minutes. Extrude with single screw, dicing to desirable size, then drying for 55°C for 4 hours, packing and storage.

Sweet potato jelly

Purple coloured, attractive and transparent jelly could be prepared from purple fleshed sweet potato extract with the help of sugar, pectin and citric acid. The preparation method includes; Selection of good quality tubers, washing, peeling and cutting into slices. Add water into slices (1:1), boil and collect the strained sweet potato extract for jelly preparation. Add sugar (60%), pectin (1%) and citric acid (0.5%). Check the TSS (Total soluble solids) by refractometer to maintain the TSS (67.5°Brix). Fill the hot product into glass bottles followed by sealing, cooling and storage (Photo 117c).

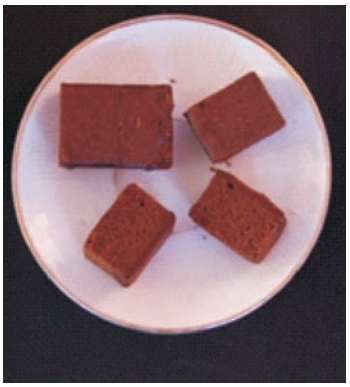


Photo 117a. Sweet potato cake

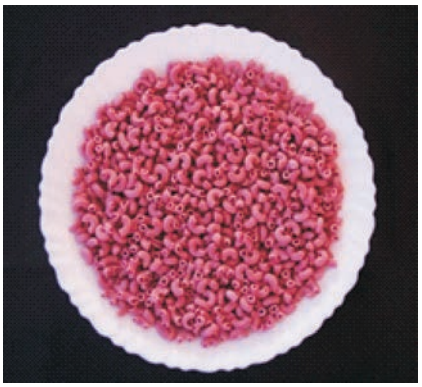


Photo 117b. Sweet potato pasta

Photo 117c. Sweet potato jelly

9.4. Value added product from arrowroot

At present in Odisha only arrowroots are used for processing into starch. InOdisha, three types of arrowroots are cultivated for starch purposes. They are (1) West Indian arrowroot (*Maranta arundinacea*), (2) East Indian arrowroot (*Curcuma* spp.) and (3) Queensland arrowroot (*Canna edulis*). The starch is extracted by traditional methods from the above three arrowroot crops by the farmers as an off-seasonal activity and marketed locally. The starch is mainly used as a functional food. Local farmers consume arrowroot starch by dissolving in milk or warm water for instant energy during diarrhoea and other stomach ailment.

Arrowroot is grown for cash income. Ninety percent of the starch produced is sold in the local market and 10% is kept for household consumption. Arrowroot starch extraction starts February month and continue up to June month every year. It is a main off-season activity of the farmers. Local traders' visits villages during this period and collect the starch. The local traders sell the starch to the exporters. Some time, local traders keep middlemen (brokers) in the villages for collecting the starch. Local traders or middlemen on behalf of local traders negotiate the rate for the starch. KASAM, an NGO based in Odisha exports 100-200 tonnes of arrowroot starch to Germany every year. However, the starch extracted by traditional method is having lot of impurities. Starch is extracted in unhygienic method. Starch extraction by traditional method consumes lot of labour and it is drudgery.

The ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram has developed multi crop mobile starch extraction machine, in which *Canna, Curcuma, Maranata*, cassava and sweet potato tubers can be crushed for starch extraction. The efficiency of the machine is 20 kg/hour, whereas traditional method it is one kg per hour (Table 34). The starch recovery is 20%, whereas traditional method, it is 10-12%. Through the machine, apart from reduction of drudgery, quality of the starch can be maintained.

The Regional Centre of ICAR-CTCRI during the year 2013, a mobile starch extraction machine was installed at Lentrimaliguda (Village), Koraput Block, Koraput disrict, Odisha under TSP. All the farmers from Lentrimaliguda were allowed to use the machine. During the year 2013, approximately 1250 kg starch was produced in this village from canna using the mobile starch extraction machine. During the year 2014, a mobile starch extraction machine was introduced in a Pottamaliguda village, Koraput Block, Koraput District, Odisha under CIP-IFAD and TSP. Through this machine 750 kg starch was extracted from 3700 kg canna tubers. Farmers from Koraput district realized the benefits of starch machine. They modified the machine as per their economical conditions in such a way that machine is mainly used for pulping (crushing) the canna tubers. Rest of the operations were carried out by traditional way. Pulping (crushing) is the biggest drudgery in the starch extraction process. At present (the year 2022), approximately 250 starch extraction machines are under operation in Koraput district.

Table 34. Efficiency of mobile starch extraction machine

Particulars	Traditional method	Starch extraction machine
Efficiency	1 kg/hour	20 kg/hour
Starch recovery from *Canna* (*palua*)	12%	20%
Electricity charges	-	1.1 unit/20 kg
Extraction charges	Own labour	Rs 1.00/kg (Rs 0.75 labour charge + 0.25 sustainability fund)

9.5. Value added product preparation demonstrated at villages

At harvesting season, value added product preparations were demonstrated in the villages. All the women farmers and youths were trained to prepare fried chips from cassava and sweet potato

Photo 118. Cassava chips production

fresh tubers (Photo 118, 119 and 120). Farmers also trained on flour preparation from cassava and sweet potato. Using cassava and sweet potato flour, snack foods like sev, murukku, gantia etc. also demonstrated in the villages. Starch extraction from Queensland arrowroot using mobile starch extraction machine was demonstrated in Lentrimaliguda village (Photo 121 and 122). Mobile starch extraction machine is very much useful to the tribal farmers. It reduces drudgery of crushing the tubers and recovery of starch is more with starch extraction machine.

Photo 119. Cassava chips and snack food preparation

Photo 120. Sweet potato (Bhu Krishna variety) chips preparation

Photo 121. Queensland arrowroot (Canna edulis) starch extraction at Lentrimaliguda, Koraput through mobile starch extraction machine

Photo 122. Cassava starch extraction at Koraput through mobile starch extraction machine

10. TECHNO INCUBATION CENTRE (TIC)

Techno-Incubation Centre was established at the Regional Centre of ICAR-CTCRI, Bhubaneswar with the financial support of RKVY, Odisha. Equipment related to production of pasta, extruded products, chips and snack foods as well as packing machines were procured and installed. Dr. Trilochan Mohapatra, Secretary (DARE) & Director General of ICAR, New Delhi inaugurated the Techno Incubation Centre in presence of Dr. Archana Mukherjee, Director, ICAR-CTCRI, Thiruvananthapuram and Dr. M. Nedunchezhiyan, Head(i/c), Regional Centre of ICAR-CTCRI, Bhubaneswar on 18.11.2017 (Photo 123). More than 100 entrepreneurs participated in the inaugural programme apart from other dignitaries. A batch of 20 persons were trained on value addition and entrepreneurship development in tuber crops (Photo 124).

Photo 123. Inauguration of techno incubation Centre Dr. Trilochan Mohapatra, Secretary (DARE) & Director General of ICAR, New Delhi

Photo 124. Techno Incubation Centre

Under TSP, every year three days training programmes were organized for the tribal beneficiaries to impart training on pasta, kurkure, cake, bread, cookies, papad, jam and jelly products preparation from cassava as well as sweet potato in techno incubation centre. Further SHG also given training on value addition of tuber crops in techno incubation centre (Photo 125, 126, 127, 128, 129 and 130).

Photo 125. Sweet potato peeling for chips and flour making

Photo 126. Slicing of sweet potato tubers

Photo 127. Preparation of sweet potato flour for snack food

Photo 128. Preparation of sweet potato-based snack food (stick and sev)

Photo 129. Preparation for papad from sweet potato

Photo 130. Pasta preparation from cassava flour

11. ENTREPRENEURSHIP DEVELOPMENT IN TUBER CROPS

Progressive tribal farmers, farmers associations and tribal youth were encouraged to become entrepreneur in tuber crops planting material production and development of value-added products and marketing.

A group of tribal farmers from Dayanidhiguda village, Koraput formed an association and started producing tuber crops quality planting materials with the help of ICAR-CTCRI and FoodSTART (CIP-IFAD) (Photo 131 and 132). After selling, farmers share the income.

Photo 131. Tuber crops nursery at Dayanidhiguda, Koraput

Photo 132. Tuber crops nursery at Dayanidhiguda, Koraput

Seed/planting materials growers are identified to supply planting materials for sustainable tuber crops cultivation apart from beneficiaries were advised to produce/keep their own planting materials. The following farmers growing seed/ planting materials of tuber crops and selling as seed materials (Table 35).

Table 35. Details of tuber crops seed/ planting materials producing farmers

Sl. No.	Name	District	Crop	Mobile no.
1	Mr. Kasinatha Majhi	Kandhamal	Sweet potato (Bhu Krishna)	9439569915
2	Mr. Rajib Patra	Kandhamal	Sweet potato (Bhu Krishna and Bhu Sona), Yam bean (RM-1)	9692464348
3	Smt. Nishanta Majhi	Kandhamal	Sweet potato (Bhu Sona and Bhu Krishna), yam bean (RM-1) and greater yam (Orissa Elite)	7008447858
4	Mr. Rajkumar Behera	Kandhamal	Sweet potato (Bhu Sona and Bhu Krishna), yam bean (RM-1), elephant foot yam (Gajendra) and greater yam (Orissa Elite)	9583330057
5	Mr. Ranjan Ku. Nayak	Gajapati	Sweet potato (Bhu Sona and Bhu Krishna), yam bean (RM-1) and greater yam (Orissa Elite)	7735991680
6	Mr. Badal Ku. Mising	Koraput	Sweet potato (Bhu Sona and Bhu Krishna) and greater yam (Orissa Elite)	773553256
7	Mr. Babulal Pamiya	Koraput	Sweet potato (Bhu Sona and Bhu Krishna) and greater yam (Orissa Elite)	9348484587
8	Mr. Durjya Mali	Koraput	Yam bean (RM-1)	Lentrimaliguda (village)
9	Mr. Dasaratha Mali	Koraput	Yam bean (RM-1)	Lentrimaliguda (village)

Many progressive tribal farmers started Queensland arrowroot starch production through mobile starch extraction machine and marketing (Photo 133). Tribal youth started chips production from cassava and sweet potato and started marketing at village huts.

Photo 133. Tribal farmer producing starch and selling in the market

The ICAR-CTCRI has encouraged entrepreneurs to procure tubers from tribal farmers for direct marketing and developing value added products. The ICAR-CTCRI has also provided Techno Incubation facilities to such entrepreneurs to utilize for value added product development on nominal rental charges till they establish in the market and developing own facilities (Photo 134).

Photo 134. Mr. Govind Swain procuring tubers from tribal farmers and utilizing ICAR-CTCRI, TIC for value-added product preparation.

Agri-startup Meet: Horti-Technology Incubation for Agri-startup and Entrepreneurship Development in Odisha" was organized by the Regional Centre of ICAR – Central Tuber Crops Research Institute, Bhubaneswar on 18.11.2017. Dr. Trilochan Mohapatra, Secretary (DARE) & DG of ICAR, New Delhi while inaugurating opined that creating sustainable horticultural enterprises including startups are the key for making Odisha as leading horticulture hub of the nation (Photo 135). Further he stressed that the ICAR Institutes, Orissa University of Agriculture & Technology, public sector entrepreneurship development agencies should work together to support budding entrepreneurs to harness the opportunities offered by recent technological advancement, market expansion and policy changes in the state. The Director General called for developing collaborative networks to catalyse agri-startups in the state. Dignitaries like Dr. R.C. Agrawal, Registrar General, PPV&FRA, New Delhi; Dr. Sanjeev Saxena, Assistant Director General, IP&TM, ICAR, New Delhi; Dr. Ajay Parida, Director, Institute of Life Sciences, Bhubaneswar; Dr. Subhrendu Sekhar Dey, Managing Director, APICOL (The Agricultural Promotion & Investment Corporation of Odisha Limited), Bhubaneswar, Dr. L.N. Gadanayak, Dean (College of Agriculture) & Vice Chancellor (Acting), OUAT, Bhubaneswar along with Directors and Scientists of ICAR Institutes in Odisha were present at the inauguration.

Dr. Archana Mukherjee, Director, ICAR-CTCRI, Thiruvananthapuram and Dr. M. Nedunchezhiyan, Head(i/c), Regional Centre of ICAR-CTCRI, Bhubaneswar welcomed the dignitaries and other participants. At the "Discussion on horticultural technology incubation and agri-startups" the Director General has interacted with several budding entrepreneurs from Odisha and has suggested to developing sound business models for value addition of tuber crops, mushroom production and processing; seed enterprise for producing quality seed materials of rice, vegetables and mango for developing Odisha as horticulture hub (Photo 136a). Representatives from startup promotion agencies like Startup Mission Odisha, APICOL and Technology Business Incubator, KIIT University explained various schemes available for promotion of startups in Odisha. Dr. Suda Mysore, Principal Scientist, ICAR-IIHR, Bangalore explained operational guidelines and IPR issues in Technology based Incubation Centres. More than 100 entrepreneurs participated in the programme.

Photo 135. Dr. Trilochan Mohapatra, Secretary (DARE) & DG of ICAR, New Delhi inaugurated Agri-startup meet

Photo 136a. Interface with entrepreneurs in Agri-startup meet

12. MARKETING LINKAGES

Market linkage was developed to sell the tubers at higher price (Photo 136b). Arrangements were made to lift the harvested produce from tribal farmer's fields. After harvest of the tubers, farmers were advised to clean the tubers free from soil. In case sweet potato, cassava, taro and yam bean, the tubers were washed and dried before packing. Greater yam and elephant foot yam tubers were cleaned free from soil. The cleaned and packed tubers were stored in well ventilated place before marketing. The following firms/companies purchased tubers directly from the tribal farmers.

1. **Mati farms**
   Jagatpur Industrial Estate, Nehru Colony
   Vinayaka Nagar, Jagatpur-754021, Odisha
   www.matifarms.com
2. **Hain Future Natural Products Pvt Ltd**
   Plot No. 37, India Food Park
   Vasanthanarshapura, Industrial Area Phase III
   Kora Hobli, Tumkur, Karnataka, India
   chandrakumar@hainfuture.com
3. **OMM Agrotech & Services**
   Plot No. K8/1190, Kalinga Nagar, Ghatikia,
   Bhubaneswar-751003
   Ommagrotech.services@gmail.com
4. **Taptapani farmers producer company Ltd.**
   Kharidhepa, Chandiput, Mohana-761017,
   Gajapati, Odisha, taptapanifpcl@gmail.com
5. **Coastal Corporation Limited**
   15-1-37/3, Nowroji Road, Maharanipeta,
   Visakhapatnam-530002, India
   tvalsaraj@coastalcorp.co.in/www.coastalcorp.co.in
6. **Maruthi foods**
   Chaitanya Vihar, 3rd Lane, Nimakhandi Road
   Village/GP: Locahpada, Berhampur-760001
   foodsmaruti@gmail.com/ ww.marutifood.in
7. **Ranjeeta's Agri-Foods**
   Health and Hygiene Pvt. Ltd
   Bhubaneswar-752101

Photo 136b. Sale of yam bean

9. INFORMATION SERVICES AND EXTENSION COMMUNICATION (ISEC) MATERIALS

Information and extension communication materials are very essential for farmers to refresh their knowledge on crops, to verify and check pest and diseases and their management. Under TSP, booklets, brochures and leaflets on tuber crops were published in Oriya, Hindi and English for creating awareness on scientific method of tuber crops cultivation and development of value added products to the tribal farmers of Odisha, Jharkhand and Chhattisgarh states. The IEC materials were distributed to the farmers before start of the demonstrations and also distributed during training programme (Photo 137, 138 and 139).

Photo 137. Booklet on tuber crops

Photo 138. Leaflets on tuber crops

Photo 139. Folder on tuber greater yam+maize intercropping

14. AWARDS

The Regional Centre of ICAR-CTCRI has participated in award competitions and show cased tuber crops technologies. It has participated in SKOCH award technology in 2020. This Centre bagged Gold award for our work 'Livelihood improvement of tribal farmers through tuber crops technologies (Photo 140). In COVID-19 rehabilitation programme competition, this Centre has reached to semi-final (Photo 141).

Photo 141. Semi-finalist in COVID-19 rehabilitation programme

Photo 140.Technology Gold Skoch award

15. SUCCESS STORIES

Cultivation of biofortified and high yielding tuber crops varieties, improved cropping systems and integrated pest management resulted in higher yield and income which improved the food and nutrition security of the tribal farmers. Farming of backyard poultry, duck, goat and pig supplement the farm income to improve livelihoods of the farmers. Marketing arrangements made to procure the tubers from the farm gate with reasonably higher price than market price increased the confidence of tuber crops farmers. As the demand for biofortified and high yielding tuber crops varieties increased many farmers turned in to seed/ planting materials grower. Success story of the few farmers are given below.

1. Crop diversification through tuber crops for higher yield and income

Bidiapadar village is situated under Chahali GP of Chakapad block in Kandhamal district of Odisha. The village is 2 km distance from GP head quarter and 10 km distance from Block. The village is comprising 31 tribal households and they belongs to 'Kandha' tribe. Tapai Kanhar is one of the inhabitant of the village living with her husband and three children. The family is totally dependent on agriculture and the income is not adequate to manage the family. As all of the children are going to school they have to earn more income to manage their family.

Photo 142. Tapai in her field with son and husband

During the year 2013-14, ICAR-CTCRI has adopted the village to cultivate tuber crops. During the village level meeting the villagers decided to cultivate six varieties oftuber crops in their field. Tapai Kanhara is an aggressive lady farmer of the village. She always supports her husband in the agriculture work and good knowledge on farming system. She is much interested to cultivate the tuber crops in her field because she never seen the crops like elephant foot yam, cassava, yam bean, orange flesh sweet potato. She kept 0.2 ha of upland ready for

Photo 143. Dr. Nedunchezian with Tapai's Family

planting of tuber crops. After getting planting materials of tuber crops from ICAR-CTCRI, she has planted all the tuber crops in her 0.2 ha of upland. At the time of planting Dr. M. Nedunchezhiyan visited the field and explained to her how to plant the tuber crops and seed treatment to be followed. The crops were monitored by regular field visits (Photo 142 and 143). At maturity the crops were harvested. she has harvested 745 kg of sweet potato (orange flesh variety Bhu Sona) from 0.06 ha, 720 kg yam bean (RM-1) from 0.06 ha, 295 kg greater yam (Orissa Elite) from 0.02 ha, 245 kg colocasia (Muktakeshi) from 0.02 ha, 310 kg elephant foot yam (Gajendra) from 0.02 ha and 210 kg cassava (Sree Jaya) from 0.02 ha. Earlier she used to harvest 360 kg rice from 0.2 ha. Crop diversification with tuber crops resulted in 2525 kg tubers from 0.2 ha (Nedunchezhiyan and Sahoo, 2019). The gross income from all the tuber crops was Rs 33100/0.2 ha, whereas earlier from rice she used to get only Rs 7500/0.2 ha. She received Rs 25600 more than normal. She hasalso got vegetable seed support from ICAR-CTCRI and harvested 210 kg of vegetables worth of Rs 2100. She has kept part of the tubers and vegetables for her family consumption and the remaining she has sold in the market for Rs 20000. Now she is very happy and extended her gratitude's to ICAR-CTCRI for the support and advice to cultivate the tuber crops. Now she has preserved 6 types of tuber crops and 3 types of vegetables for next season cultivation.

2. Food and nutrition security through tuber crops technologies

Ghasi Mallick aged about 52 years is a tribal farmer residing in Bidiapadar village which is coming under Chahali GP of Chakapad Block. Bidiapadar is one of the interior village of Chakapad block. He is a 'Kandha' tribe and has 0.8 ha of land and out that 0.4 ha is upland and 0.4 ha and medium land. Out of 0.4 ha upland,0.2 ha is barren land and not cultivating. In medium land he is cultivating paddy and maize, and millet in upland.

Photo 144. Mr. Sanyasi and Ghasi Mallick in tuber crop field

During the year 2013-14, with the support of ICAR-CTCRI he has cultivated six types of tuber crops in the 0.2 ha barren land and five types of vegetable in backyard garden. He got interest on tuber crops cultivation after attending tuber crops training programme organized by Dr. M. Nedunchezhiyan, Principal Scientist, Regional Centre of ICAR-CTCRI, Bhubaneswar at Bidiapadar village. The training was facilitated by ORRISSA (NGO). He wanted to use the half acre barren land for tuber crops cultivation. Some of the tuber crops were not seen by him earlier. The crops were monitored by regular field visits by Scientists from the ICAR-CTCRI (Photo 144 and 145). At maturity the crops were harvested. Ghasi Mallick has harvested 260 kg greater yam (Orissa Elite) from 0.02 ha, 230 kg colocasia (Muktakeshi) from 0.02 ha, 255 kg elephant foot yam (Gajendra) from 0.02 ha,

710 kg of sweet potato (Bhu Sona) from 0.06 ha, 680 kg yam bean (RM-1) from 0.06 ha, and 210 kg cassava (Sree Jaya) from 0.02 ha. Earlier he was getting nothing in this barren 0.2 ha land and now he got 2415 kg tubers. If at all millets are sown, the yield will be 210 kg/0.2 ha with the gross income of Rs 6300. Now, he received the gross income of Rs 31275/0.2 ha. He has also got vegetable seed support from ICAR-CTCRI and harvested 240 kg of vegetables worth of Rs 2400.

Photo 145. Ghasi Mallick in his tuber crop field

He has kept part of the tubers and vegetables for his household consumption and the remaining sold in the market for Rs 15000. Now he is very happy and eating nutritious foods produced from his farm. His family has attained food and nutrition security. The cash income was used for other household purposes. He has extended his warm regards to ICAR-CTCRI for the support and advice to cultivate the tuber crops. He said that he will advise other farmers also to cultivate tuber crops and he would like to extend area under tuber crops in next season. He has preserved 6 types of tuber crops and 5 types of vegetables for next season cultivation.

3. Tuber crops-based farming system brings smile on the face of Sunandini Kanhar

Sunandini Kanhar is a small poor tribal farm woman lives in Mallickpada (village), Bafallomendi (GP), Chakapada (Block), Kandhamal (district). She belongs to 'Kandha' tribe. The village is situating in the foot hill. Sunandini Kanhar is having 0.6 ha of upland. She is having a diseased husband, a daughter and a son. Her daughter and son were helping her in farming. In her 0.6 ha of upland, usually she cultivates 0.4 ha rice and 0.2 ha ragi during rainy season. The rice and ragi yields were very low as she cultivates in traditional method. Rice and ragi were broad casted and then thinning the crop. Because of broad casting no proper spacing is maintained that hampering weeding and other intercultural operations.

Under TSP, the tribal farmer Sunandini Kanhar was adopted during 2014-15 and discussed about tuber crops-based farming system model. We informed her under the project only critical inputs will be given. She has to contribute labour, manures and others required for cultivation. She agreed for the same. Out of 0.6 ha, 0.4 ha was brought under tuber crops-based farming system. The 0.4 ha farming system model includes cereals, millets, pulses, tuber crops, vegetables and backyard poultry (Photo 146, 147 and 148). Cereals and pulses were sown in line as per recommended spacing. Tuber crop technologies were introduced as per recommended methods. Vegetable cultivation also followed scientific way. Fencing materials were given for protecting tuber crops and vegetables from grazing animals and anti-social. She was also given small farm implements to carry out field operations.

Earlier Sunandini Kanhar used to harvest 700 kg rice from 0.4 ha. After line sowing with other package of practices, she has harvested 610 kg of rice from 0.2 ha, 63 kg of maize from 0.03 ha, 22 kg of ragi from 0.02 ha, 520 kg of sweet potato (orange flesh variety Bhu Sona) from 0.04 ha, 370 kg yam bean from 0.03 ha, 288 kg greater yam from 0.02 ha, 255 kg colocasia from 0.02 ha, 95 kg elephant foot yam from 0.008 ha, 20 kg cassava from 0.002 ha and 130 kg vegetables (ridge gourd, bitter gourd, bhendi, amaranthus etc.) from 0.01 ha (Table 36). She is getting more employment and through-out the year from her farm.

A bright smile is seen on the face of Sunandini Kanhar. She got her family requirement of cereals, millets, pulses, vegetables, tubers eggs and meat. She is eating balanced food now. She is also getting some cash through the sale of vegetables, sweet potato and others.

Table 36. Farming system involving tuber crops (0.4 ha model) in Sunandini Kanhar field

Sl. No.	Crop	Area (ha)	Yield (kg)	Gross income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C ratio	Employment generation (Man-days)
1	Rice	0.20	610	12200	6000	6200	2.03	48
2	Maize	0.03	63	945	380	565	2.49	3
2	Ragi	0.02	22	440	180	260	2.44	1
3	Redgram	0.02	18	900	300	600	3.00	2
4	Sweet potato	0.04	520	5200	1400	3800	4.00	9
5	Yam bean	0.03	370	5550	1300	4250	4.27	8
6	Greater yam	0.02	288	5760	2000	3760	2.88	12
7	Colocasia	0.02	255	5100	1300	3800	3.92	9
8	Elephant foot yam	0.008	95	1900	550	1350	3.45	4
9	Cassava	0.002	20	200	100	100	2.00	1
10	Vegetable (*Amaranthus*, Bhendi, bitter gourd, ridge gourd etc.)	0.01	130	2600	900	1700	2.89	5
11	Backyard poultry	20 (nos.)	42+376 eggs	5040+ 1880	2000	4920	3.46	7
	Total	**0.4**	**2433 + 376 eggs**	**47715**	**16410**	**31305**	**2.91**	**109**

*Sale price of rice rice Rs 20/kg, maize Rs 15/kg, ragi Rs 20/kg, redgram Rs 50/kg, sweet potato Rs 10/kg, yam bean Rs 15/kg, greater yam Rs 20/kg, colocasia Rs 20/kg, elephant foot yam Rs 20/kg, cassava Rs 10/kg, vegetables Rs 20/kg, poultry meat Rs 120/kg and egg Rs 5/egg.

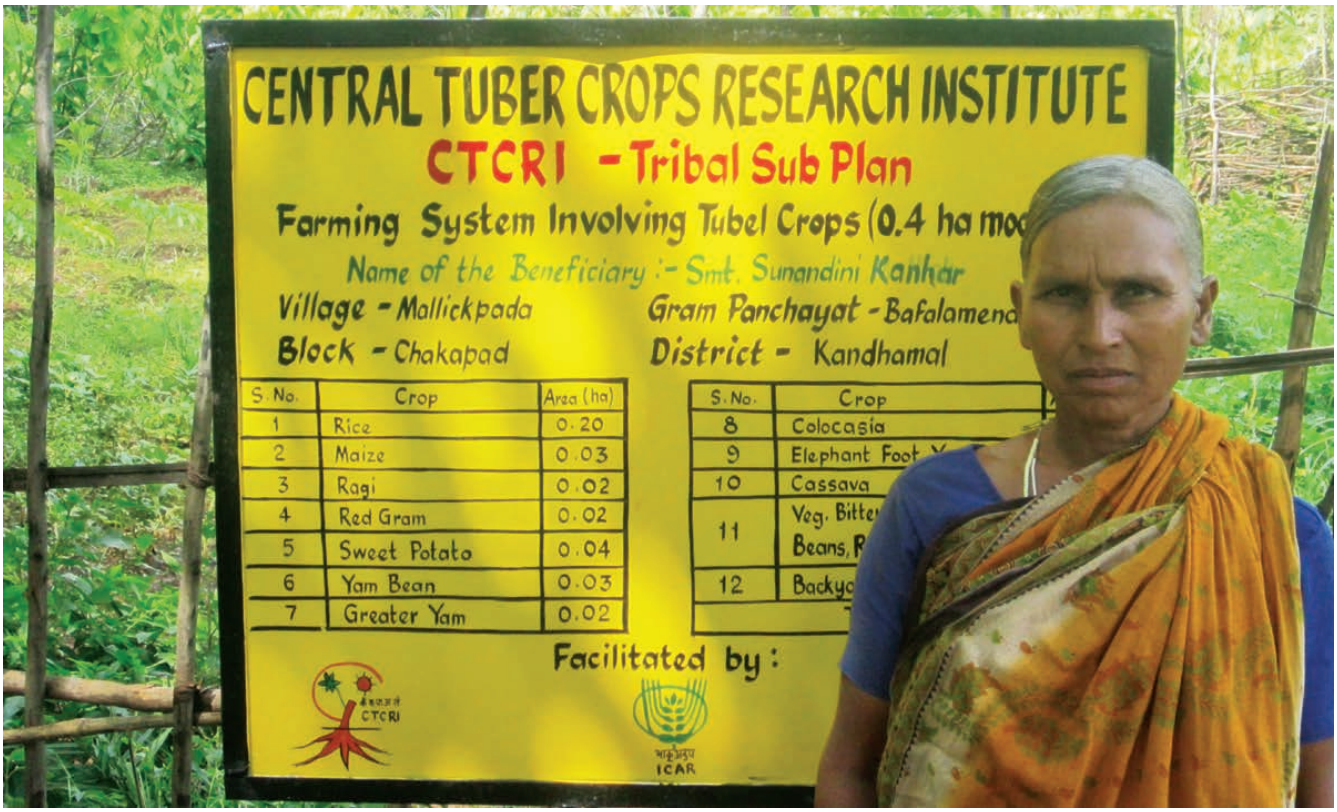


Photo 146. Farming system involving tuber crops (0.4 ha model) at Mallickpada village, Kandhmal district of Odisha

Photo 147. Farming system involving tuber crops (0.4 ha model) in Smt. Sunandini Kanhar field at Mallickpada village, Kandhmal district of Odisha

Photo 148. Smt. Sunandini Kanhar with her chicks

4. Tuber crops technologies for income generation and livelihood improvement of women farmers

Smt. Menaka Kanhar lives in a tribal village Kenjaguda, Chakapada (block), Kandhamal district. She belongs to 'Kandha' tribe. She lives with diseased husband and two children. Children are studying in 5th and 3rd class in Govt school. She has 0.8 ha upland. Usually she cultivates rice, ragi and maize in her uplands. She gets meagre income from her field because of lower yield. But her expenditures are high because of children education and husband's medicines. Smt. Menaka Kanhar is an innovative tribal farm woman. She always like to do new things in her farming. When she heard about tuber crops technologies, she immediately contacted Dr. M. Nedunchezhiyan, Principal Scientist, Regional Centre of ICAR-CTCRI, Bhubaneswar through ORRISSA (NGO). During 2016-17 cropping season Dr. M. Nedunchezhiyan discussed with her and introduced tuber crops in her 0.2 ha upland field. The area of tuber crops was given in the Table 37. The tuber crops planting materials and maize seeds were given her free of cost. The crop was monitored regularly by ICAR-CTCRI scientists by field visits (Photo 149).

At harvest, Smt. Menaka Kanhar got 3401 kg of tubers and seeds from her 0.2 ha upland. Earlier in same area of land she used to get 300-400 kg seeds only. Crop diversification with tuber crops resulted in gross income of Rs 46630/0.2 ha, whereas earlier from rice Smt. Menaka Kanhar used to get only Rs 7500/0.2 ha. Now she realized that tuber crops only save her from debt. She has sufficient tubers for her household consumption and selling. Smt. Menaka Kanhar and her family are getting

balanced nutrition through tuber crops. Cash income from tuber crops also taking care of her husband health and children education. Now she is very happy and extended her gratitude's to ICAR-CTCRI for the support and advice to cultivate the tuber crops. Smt. Menaka Kanhar has preserved sufficient planting materials of 5 types of tuber crops for next season cultivation. She also wanted to cultivate more area under tuber crops.The farmers in the vicinity are also visited the tuber crops fields and impressed very much by seeing the tuber crops and requested ICAR-CTCRI to support them next season.

Table 37. Tuber crops area, yield and economics

Crops/Other components	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C ratio	Employment generation (Man-days)
Greater yam+maize	0.04	924 + 100	15360	5600	9760	2.74	22
Elephant foot yam	0.03	705	10575	3900	6675	2.71	18
Sweet potato	0.06	715	7150	2400	4750	2.98	13
Yam bean	0.06	795	11925	2950	8975	4.04	16
Cassava	0.01	162	1620	600	1020	2.70	5
Total	**0.2**	**3401**	**46630**	**15450**	**31180**	**3.02**	**74**

*Sale price of sweet potato Rs 10/kg, yam bean Rs 15/kg, greater yam Rs 15/kg, elephant foot yam Rs 15/kg and cassava Rs 10/kg.

Photo 149. Smt. Menaka Kanhar in greater yam+maize intercropping field

5. Tuber crops-based farming system for food and nutrition security and livelihood improvement of Bayadhar Pujari

Mr. Bayadhar Pujari, a saura tribe from Anangadongra village, Jeerango GP, Mohana block, Gajapati district of Odisha was worried more about declining of maize yield year after year from his field. During the year 2017-18, he got 605 kg maize seed yield from his 0.2 ha field (Table 38). He is unable to give good food for school going his three children. He has contacted Dr. M. Nedunchezhiyan, Principal Scientist, Regional Centre of ICAR-CTCRI, Bhubaneswar through Mr. Gopinath Sahoo, HEW, Department of Horticulture, Chandragiri, Mohana Block, Gajapati district. During 2018-19 cropping season Dr. M. Nedunchezhiyan discussed with him about tuber crops and their yield potential and assured him marketing of the produce. He was having o.4 ha upland, in which he was willing to give 0.2 ha upland for carrying out tuber crops-based farming system (0.2 ha model). In this 0.2 ha model the area of various crop components was as follows: maize 0.08 ha, greater yam+maize intercropping 0.03 ha, sweet potato 0.04 ha, yam bean 0.04 ha, cassava 0.01 ha. All the above crop components were sown/ planted during *kharif* season. The tuber crops planting materials like sweet potato (Bhu Krishna), cassava (Sree Vijaya), greater yam (Orissa Elite), maize and yam bean (RM-1) seeds were given to the farmer. A vegetable kit (contains *Amaranthus*, bhendi, chilli, onion, cowpea, French bean, *Dolichos* and bottle gourd seeds) and 10 poultry birds (Vanaraja) were also given to the farmer to include in the farming system. Vegetables were grown in *rabi* season in 0.01 ha. Farmer also contributed maize seed. The crop and animal components were monitored regularly to address the problem faced by the farmer (Photo 150 and 151).

Tubers of different species were harvested at maturity. The details of yields and returns were presented in the Table 39. Now the farmer harvested 2484 kg of seeds, tubers and vegetables in place of 605 kg maize seeds. Earlier Mr. Bayadhar Pujari was getting income of Rs 9075 from 0.2 ha, now he is getting Rs 38505 from 0.2 ha. The tuber crops-based farming system has generated more employment of 79 man-days from 0.2 ha and spread throughout the year. Some portion of the produce was consumed by the family, while other portion sold in local market.

Now Mr. Bayadhar Pujari is very happy and eating nutritious foods produced from his farm. His family has attained food and nutrition security. The cash income generated through this farming system was used for other house-hold purchases. He has extended his warm regards to ICAR-CTCRI for the support and advice to cultivate the tuber crops. Mr. Bayadhar Pujari said that he will advise other farmers also to cultivate tuber crops and he would like to extend area under tuber crops in next season. He has preserved sufficient quantity of tuber crops planting materials for next season cultivation.

Table 38. Crop yield and economics prior to intervention

Crops/Other components	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C ratio	Employment generation (Man-days)
Maize	0.2	605	9075	5000	4075	1.82	45

*Sale price of maize Rs 15/kg.

Table 39. Component-wise yield and economics of tuber crops-based farming system (0.2 ha model)

Crops/Other components	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C ratio	Employment generation (Man-days)
Maize	0.08	322	4830	2200	2630	2.20	15
Greater yam+ maize	0.03	605+ 112	9075+ 1680	3300	7455	3.26	19
Sweet potato	0.04	516	5160	1900	3260	2.72	10
Yam bean	0.04	552	8280	1800	6480	4.60	10
Cassava	0.01	165	1650	700	950	2.36	4
Vegetable (*rabi*)	0.01	212	4240	1625	2615	2.61	13
Backyard poultry	10 Nos.	22+190 Nos. eggs	2640 + 950	900	2690	3.99	8
Total	**0.2**	**2506 + 190 Nos. eggs**	**38505**	**12425**	**26080**	**3.10**	**79**

*Sale price of maize Rs 15/kg, greater yam Rs 15/kg, sweet potato Rs 10/kg, yam bean Rs 15/kg, cassava Rs 10/kg, vegetables Rs 20/kg, poultry meat Rs 120/kg and egg Rs 5/egg.

Photo 150. Mr. Bayadhar Pujari with his yam bean harvest

Photo 151. Mr. Bayadhar Pujari with his harvested maize and chickens

6. Adoption of tuber crops-based farming system brings higher economic returns and livelihood improvement to a tribal farmer in Kandhamal, Odisha

Mr. Rabindra Pradhan, a 'Kandha' tribe lives in Budukakhol village, Kakharujhola GP, Chakapada (block), Kandhamal (district), Odisha. He is having 0.8 ha upland and cultivating rice, maize and ragi. But he gets meagre yield and income which is not sufficient for sustaining his family (wife and 3 children). He was worried about his wife ill health and children's education. Dr. M. Nedunchezhiyan discussed with him about importance of tuber crops in the changing climate and tuber crops-based farming system (0.2 ha model). Mr. Rabindra Pradhan agreed to allot 0.2 ha upland for carrying out tuber crops-based farming system during 2019-20 cropping season. The Regional Centre of ICAR-CTCRI has given quality planting materials of tuber crops along with seeds of improved varieties of maize, red gram and vegetables. Vegetable seed kit includes *Amaranthus*, bhendi, chilli, onion, cowpea, French bean, *Dolichos* and bottle gourd seeds. Vegetable cultivation was taken in 0.01 ha during *rabi* season. Backyard poultry 20 nos. (45 days old) was given to the farmer to supplement farm income. The crop and animal components were monitored regularly by field visits by the scientists from the Regional Centre of ICAR-CTCRI (Photo 152).

At maturity crops were harvested. The details of yields and returns were presented in the Table 40. Mr. Rabindra Pradhan has harvested 230 kg maize seeds from sole crop (0.05 ha), 590+125 kg greater yam tubers+maize seeds, respectively (0.03 ha), 532 kg elephant foot yam tubers (0.02 ha),

190 kg taro tubers (0.01 ha), 510+32 kg sweet potato tubers+red gram seeds (0.04 ha), 565 kg yam bean tubers (0.04 ha) and 168 kg cassava tubers (0.01 ha). Vegetables 214 kg harvested from 0.01 ha during *rabi* season. Backyard poultry 20 nos. (45 days old) resulted in 45 kg meat and 395 eggs. Earlier Mr. Rabindra Pradhan was getting income of Rs 9825 from 0.2 ha by cultivating maize (Table 41), now he is getting Rs 54305 from 0.2 ha (Table 40). The tuber crops-based farming system also generated more employment of 94 man-days from 0.2 ha and spread throughout the year. Part of the yield, he has kept for household consumption and the remaining portion sold in local market.

Now Mr. Rabindra Pradhan and his family are very happy and eating nutritious foods produced from his farm. His family has attained food and nutrition security. The cash income generated through this farming system was used for other house-hold purchases. Mr. Rabindra Pradhan has extended his gratitude to ICAR-CTCRI for the support and advice to cultivate the tuber crops. He said that he will advise other farmers also to cultivate tuber crops and he would like to extend area under tuber crops in next season. He has preserved sufficient quantity of tuber crops planting materials for next season cultivation.

Table 40. Component-wise yield and economics of tuber crops-based farming system (0.2 ha model)

Crops/Other components	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C ratio	Employment generation (Man-days)
Maize	0.05	230	3450	1300	2150	2.65	8
Greater yam+ maize	0.03	590+125	10725	3500	7225	3.06	20
Elephant foot yam	0.02	532	7980	2800	5180	2.85	14
Taro	0.01	190	2850	1000	1850	2.85	6
Sweet potato+red gram	0.04	510+32	5100+1280	2200	4180	2.90	10
Yam bean	0.04	565	8475	2200	6275	3.85	10
Cassava	0.01	168	2520	900	1620	2.80	6
Vegetable (*rabi*)	0.01	214	4280	1800	2480	2.38	8
Backyard poultry	20 Nos.	45+395 Nos. eggs	5400+ 1975	1800	5575	4.10	12
Total	**0.2**	**3096 +45 + 390 Nos. eggs**	**54035**	**17500**	**36535**	**3.09**	**94**

*Sale price of maize Rs 15/kg, greater yam Rs 15/kg, elephant foot yam Rs 15/kg, taro Rs 15/kg, sweet potato Rs 10/kg, yam bean Rs 15/kg, cassava Rs 15/kg, red gram Rs 40/kg, vegetables Rs 20/kg, poultry meat Rs 120/kg and egg Rs 5/egg.

Table 41. Crop yield and economics prior to intervention

Crops/Other components	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C ratio	Employment generation (Man-days)
Maize	0.2	655	9825	5100	4725	1.93	42

*Sale price of maize Rs 15/kg.

Photo 152. Mr. Rabindra Pradhan in his tuber crops-based farming system field

7. A progressive farmer Ganesh Kanhar generated higher income and improved livelihood through tuber crops-based farming system

Mr. Ganesh Kanhar, is a 'Kandha' tribe from from Phalsipadar village in Tikabali (Block), Kandhamal (District), Odisha. He is a bachelor living with his widow mother. He is having helping tendency and doing lot of social services. Mr. Ganesh Kanhar is used to experiment agricultural innovations in his field. Dr. M. Nedunchezhiyan, Principal Scientist, Regional Centre of ICAR-CTCRI, Bhubaneswar contacted him for demonstrating tuber crops-based farming system (0.4 ha model) in his field during 2020-21 cropping season for which he readily agreed. He kept the field ready within a week. The Regional Centre of ICAR-CTCRI has given him quality planting materials of tuber crops along with seeds of improved varieties of maize, red gram and vegetables at free of cost. Vegetable cultivation was taken in *rabi* season. Vegetable seeds include *Amaranthus*, bhendi, chilli, onion, cowpea, French bean, *Dolichos* and bottle gourd. Backyard poultry 20 nos. and female goats 2 nos. were also given to the farmer to supplement farm income. The crop and animal components were monitored regularly by field visits by the scientists from the Regional Centre of ICAR-CTCRI (Photo 153).

Mr. Ganesh Kanhar has harvested the crops after attaining maturity. The details of yields and returns from tuber crops-based farming system were presented in the Table 42. Mr. Ganesh Kanhar

has harvested 715 kg rice from (0.2 ha), 620+130 kg greater yam tubers+maize seeds, respectively (0.03 ha), 520 kg elephant foot yam tubers (0.02 ha), 425 kg taro tubers (0.02 ha), 770+65 kg sweet potato tubers+red gram seeds (0.06 ha), 826 kg yam bean tubers (0.06 ha) and 168 kg cassava tubers (0.01 ha). Vegetables 220 kg harvested from 0.01 ha during *rabi* season. Backyard poultry 20 nos. (45 days old) resulted in 45 kg meat and 395 eggs and black Bengal goat 32 kg. Earlier Mr. Ganesh Kanhar was getting income of Rs 37250 from 0.4 ha by cultivating rice (Table 43), now he is getting Rs 99995 from 0.4 ha (Table 42). The tuber crops-based farming system also generated more employment of 189 man-days from 0.4 ha and spread throughout the year. Mr. Ganesh Kanhar has kept part of the yield for household consumption and the remaining portions sold in local market.

Now Mr. Ganesh Kanhar and his widow mother are very happy and eating nutritious foods produced from his farm. His family has attained food and nutrition security. The cash income generated through this farming system was used for other house-hold purchases. Mr. Ganesh Kanhar has extended his gratitude to ICAR-CTCRI for the support and advice to cultivate the tuber crops, poultry birds and goats. He said that he will advise other farmers also to cultivate tuber crops and he would like to extend area under tuber crops in next season. He has preserved sufficient quantity of tuber crops planting materials for next season cultivation.

Table 42. Component-wise yield and economics of tuber crops-based farming system (0.4 ha model)

Crops/Other components	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C ratio	Employment generation (Man-days)
Rice	0.2	715	17875	8000	9875	2.23	52
Greater yam+ maize	0.03	620+130	11250	4750	6500	2.37	25
Sweet potato+red gram	0.06	770+65	10300	3600	6700	2.86	22
Yam bean	0.06	826	12390	4100	8290	3.02	24
Elephant foot yam	0.02	520	7800	3200	4600	2.44	20
Colocasia/taro	0.02	425	6375	2375	4000	2.68	14
Cassava	0.01	168	1680	650	1030	2.58	5
Vegetable (*rabi*)	0.01	220	4400	1850	2550	2.38	13
Backyard poultry	20 Nos.	45+395 Nos. eggs	8725	2000	6725	4.36	6
Goat	2 Nos.	32	19200	9000	10200	2.13	8
Total	**0.4**	**4459 + 77 + 395 Nos. eggs**	**99995**	**39525**	**60470**	**2.53**	**189**

*Sale price of rice Rs 25/kg, maize Rs 15/kg, greater yam Rs 15/kg, sweet potato Rs 10/kg, yam bean Rs 15/kg, elephant foot yam Rs 15/kg, colocasia Rs 15/kg, cassava Rs 10/kg, red gram Rs 40/kg, vegetables Rs 20/kg, poultry meat Rs 150/kg, egg Rs 5/egg and goat meat Rs 600/kg.

Table 43. Crop yield and economics prior to intervention

Crops/Other components	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C ratio	Employment generation (Man-days)
Rice	0.4	1370	34250	18000	16250	1.90	94

*Sale price of rice Rs 25/kg.

Photo 153. Mr. Ganesh Kanhar in his farming system field at Phalsipadar village in Kandhamal district of Odisha

8. Income generation and livelihood improvement through tuber crops-based farming system in Koraput, Odisha

Koraput is a tribal dominated district in Odisha. More than 90% tribal farmers are small and marginal. Farming is the major activity of the tribals in this district. Farmers depend on south-west monsoon for their farming activity. This hilly district is having undulating land with acidic soils. Soil and water conservation is the major challenges along with food production. Mostly farmers grow rice, ragi, little millet, kodo millet, foxtail millet, maize etc. under upland ecosystem in Koraput district. The yield from these crops is very low. Income from these crops is also meagre. During lean period, farmers collect root and tubers, wild berries from the nearby forest. The Regional Centre of ICAR-CTCRI has standardized location specific tuber crops-based farming system for augmenting yield, income an employment.

Smt. Lalita Mising, W/o Tamaru Mising, Misinguda (Village), Pakjhola (GP), Semiliguda (Block), Koraput (District), Odisha (State) is always complaining to Scientists, KVK, Semiliguda about low yield and income from her field. She is having 0.4 ha upland. The yield from this 0.4 ha could not able to feed her 6 family members. She is getting 750 kg rice and 200 kg ragi from her 0.4 ha land. She gets net income of Rs 15000 only with employment of 130 man-days. Dr. Biswanath Sahoo and Dr. Manas Ranjan Nayak, Scientists, KVK, Semiliguda approached Dr. M. Nedunchezhiyan, Principal Scientist and Head & PI (TSP) to demonstrate tuber crops-based farming system developed for upland

ecosystem. Dr. M. Nedunchezhiyan laid out front line demonstration of 0.2 ha tuber crops-based farming system model in Smt. Lalita Mising field during 2021-22 under Tribal Sub-Plan (TSP). The crops and other components are as follows: Rice (0.07 ha), yam+maize (0.02 ha), sweet potato (0.04 ha), yam bean (0.04 ha), elephant foot yam (EFY) (0.005 ha), colocasia (0.005 ha) and cassava (0.01 ha) (Photo 154). Planting of the above seeds were carried out during June-July. Vegetables (*Amaranthus*, bhendi, chilli, cowpea, French bean, tomato, palak and *Dolichos* seeds) 0.01 ha seeds were cultivated. Backyard poultry 20 nos. of Kalinga Brown was also included in this farming system.

Different cereals, tubers and vegetables were harvested at maturity. Eggs were collected from the poultry bird. Some portion of the produce was consumed by the family, while other portions were sold to the local markets. The culled and damaged food materials are fed to the poultry. Tuber crops-based farming system not only increased family incomes but also employment generations. The details of return and yields are presented in the Table 44. The tuber crops-based farming system increased the net income. Earlier she was getting Rs 15000 from 0.4 ha, now she is getting Rs 28790 from 0.2 ha. The tuber crops-based farming system generated additional employment of 26 man-days from 0.2 ha.

This model could increase the farm income and food and nutrition security and alleviate the financial hardship of the marginal tribal farmer. On getting the result, farmer was much convinced that tuber crops-based farming system is a profitable venture. The farmers in the vicinity are also visited the tuber crops-based farming system model and impressed very much by seeing the system and requested for financial and technical support for them from our Centre for initiating the such model.

Photo 154. Yam and sweet potato fields of Smt. Lalita Mising (left side) visited by Smt. Basanti Pujari (middle) and Dr. M. Nedunchezhiyan (right side)

Table 44. Component wise yield and economics of tuber crops-based farming system

Crops/Other components	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C ratio	Employment generation (Man-days)
Rice	0.07	255	6375	2900	3350	2.16	17
Yam+ maize	0.02	425 + 80	7575	3500	4000	2.14	14
Sweet potato	0.04	517	5170	1800	3350	2.86	10
Yam bean	0.04	535	8025	2550	5400	3.12	12
Elephant foot yam	0.005	128	1920	900	1050	2.17	7
Colocasia	0.005	115	1725	750	975	2.3	7
Cassava	0.01	175	1750	650	1050	2.62	4
Vegetable	0.01	230	4600	1900	2300	2.21	16
Backyard poultry	20 Nos.	44 + 400 Nos. eggs	86 00	2000	6500	4.25	4
Total	**0.2**		**45740**	**16950**	**28790**	**2.70**	**91**

*Sale price of rice Rs 25/kg, maize Rs 15/kg, yam Rs 15/kg, sweet potato Rs 10/kg, yam bean Rs 15/kg, EFY Rs 15/kg, colocasia Rs 15/kg, cassava Rs 10/kg, vegetables Rs 20/kg, poultry meat Rs 150/kg and egg Rs 5/egg.

9. Tuber crops-based farming system for cash income and nutrition security

In upland ecosystem of Koraput, rice, ragi, little millet, kodo millet, foxtail millet, maize etc. are the popular crops. Sweet potato, potato and ginger are also cultivated. The yield from these crops is very low. Income from these crops is also meagre. The Regional Centre of ICAR-CTCRI has developed location specific tuber crops-based farming system models for enhancing farm income, employment and livelihood.

Basanti Pujari, D/o Angra Deulpadia, age 28 years, Misinguda (Village), Pakjhola (GP), Semiliguda (Block), Koraput (District), Odisha (State) is an active youth. She always thinking about development of tribal people. She is a social activist. She is having 0.8 ha upland. The yield and income from this 0.8 ha could not meet her family (5 members) requirements. She is getting 850 kg rice from 0.4 ha, 500 kg maize from 0.2 ha and 225 kg ragi from 0.2 ha land. She was getting net income of Rs 20000 only with employment of 260 man-days. Dr. Biswanath Sahoo and Dr. Manas Ranjan Nayak, Scientists, KVK, Semiliguda approached Dr. M. Nedunchezhiyan, Principal Scientist and Head & PI (TSP) to demonstrate tuber crops-based farming system developed for upland ecosystem in Koraput district. Dr. M. Nedunchezhiyan laid out front line demonstration of 0.2 ha tuber crops-based farming system model in Smt. Lalita Mising field during 2021-22 under Tribal Sub-Plan (TSP). The crop and other components are as follows: Rice (0.07 ha), yam+maize (0.02 ha), sweet potato

(0.04 ha), yam bean (0.04 ha), elephant foot yam (EFY) (0.005 ha), colocasia (0.005 ha) and cassava (0.01 ha) (Photo 155). Planting of the above seeds were carried out during June-July. Vegetables (*Amaranthus*, bhendi, chilli, cowpea, French bean, tomato, palak and *Dolichos* seeds) 0.01 ha seeds were cultivated. Backyard poultry 20 nos. of Kalinga Brown was also included in this farming system.

Different cereals, tubers and vegetables were harvested at maturity. Eggs were collected from the poultry bird. Some portion of the produce was consumed by the family, while other portions were sold to the local markets. The culled and damaged food materials are fed to the poultry. Tuber crops-based farming system not only increased family incomes but also employment generations. The details of return and yields are presented in the Table 45. The tuber crops-based farming system increased the net income. Earlier she was getting profit of Rs 20000 from 0.8 ha, now she is getting Rs 29005 from 0.2 ha. The tuber crops-based farming system generated more employment of 92 man-days from 0.2 ha and spread throughout the year.

This model could increase the farm income and food and nutrition security and alleviate the financial hardship of the marginal tribal farmer. On getting the result, farmer was very much convinced that tuber crops-based farming system is a profitable venture. The farmers in the vicinity are also visited the tuber crops-based farming system model and impressed very much by seeing the system and requested for financial and technical support for them from our Centre for initiating the such model.

Photo 155. Yam+maize intercropping system field of Basanti Pujari

Table 45. Component wise yield and economics of tuber crops-based farming system

Crops/Other components	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C ratio	Employment generation (Man-days)
Rice	0.07	260	6500	3000	3500	2.17	18
Yam+ maize	0.02	422 + 85	7605	3500	4105	2.17	14
Sweet potato	0.04	520	5200	1800	3400	2.89	10
Yam bean	0.04	540	8100	2550	5550	3.18	12
Elephant foot yam	0.005	130	1950	900	1050	2.17	7
Colocasia	0.005	120	1800	750	1050	2.4	7
Cassava	0.01	180	1800	700	1100	2.57	4
Vegetable	0.01	230	4600	2000	2600	2.3	16
Backyard poultry	20 Nos.	45 + 380 Nos. eggs	86 50	2000	6650	4.32	4
Total	**0.2**		**46205**	**17200**	**29005**	**2.69**	**92**

*Sale price of rice Rs 25/kg, maize Rs 15/kg, yam Rs 15/kg, sweet potato Rs 10/kg, yam bean Rs 15/kg, EFY Rs 15/kg, colocasia Rs 15/kg, cassava Rs 10/kg, vegetables Rs 20/kg, poultry meat Rs 150/kg and egg Rs 5/egg.

10. Tuber crops: A source of income for women farmers of Kandhamal

Kandhamal district is a part of eastern ghat zone of Odisha and dominated by tribal community. Agriculture is the major activity and source of livelihood for the tribals. Cultivating lands are slopy and soil is acidic in nature. Farmers depend on South-West monsoon for their farming activity. Monsoon vagaries are the major problem faced by the farmers. Intermittent long dry-spells and early cessation of monsoon are regular feature and causing huge yield losses of rainfed crops. In upland ecosystem of Kandhamal, rice and ragi are the popular crops. The yield from these crops is very low. Income from these crops is also meagre. Root and tuber crops are drought tolerant. Being non-flowering plant, intermittent dry spells are not affecting the root and tuber crops much. The plant continue growth once favourable conditions are prevailing. The short and long duration species of root and tuber crops are highly suitable for crop diversification for augmenting income and livelihood.

Smt. Sashanti Badamajhi, W/o Nishanta Badamajhi, age 48 years, Jharighati (Village), Madaguda (GP), Kotagarh (Block), Kandhamal (District), Odisha (State) is always worried about feeding and providing education to her 4 grown up children. She is having 0.4 ha upland. The yield from this 0.4 ha could not able to feed her 6 family members. She is getting 700 kg rice and 220 kg ragi from her 0.4 ha land. She gets net income of Rs 15000 only with employment of 130 man-days. Under TSP, tuber crops technologies were demonstrated in 0.2 ha in Sashanti Badamajhi field during 2021-22. Initially, she was reluctant to provide 0.2 ha because she was not sure of tuber crops performance in

Jharighati village. The tuber crops species in crop diversification included was as follows: yam (0.05 ha), sweet potato (0.06 ha), yam bean (0.04 ha), elephant foot yam (EFY) (0.03 ha), colocasia (0.01 ha) and cassava (0.01 ha) (Photo 1). Tuber crops quality planting materials of yam (Orissa Elite), sweet potato [Bhu Sona (0.03 ha) and Bhu Krishna (0.03 ha)], yam bean (RM-1), elephant foot yam (Gajendra), *Colocasia* (Muktakeshi) and cassava [Sree Jaya (0.005 ha) and Sree Vijaya (0.005 ha)] were given to the tribal farmer.

Tubers of different species were harvested at maturity. The details of return and yields were presented in the Table 46 (Photo 156). Tuber crops performance was very good and it increased family income and generated more employment. Earlier she was getting profit of Rs 15000 from 0.4 ha, now she is getting Rs 31875 from 0.2 ha (Nedunchezhiyan *et al.*, 2022). The tuber crops technologies have generated more employment of 95 man-days from 0.2 ha and spread throughout the year. Some portion of the produce was consumed by the family, while other portion was sold in local markets.

This model could increase the farm income and food and nutrition security and alleviate the financial hardship of Smt. Sashanti Badamajhi. On getting the result, Smt. Sashanti Badamajhi was very much convinced that tuber crops cultivation is a profitable venture. The farmers in the vicinity

Photo 156. Harvested tubers of yam and sweet potato in Sashanti Badamajhi field

are also visited the fields of tuber crops and impressed very much by seeing the cropping system and requested for financial and technical support for them from our Centre for initiating the such model.

Smt. Sashanti Badamajhi family has attained food and nutrition security. The cash income generated through this farming system was used for other house-hold purchases. Smt. Sashanti Badamajhi has extended his gratitude to ICAR-CTCRI for the support and advice to cultivate the tuber crops. She said that she will advise other farmers also to cultivate tuber crops and she would like to extend area under tuber crops in next season. Smt. Sashanti Badamajhi has preserved sufficient quantity of tuber crops planting materials for next season cultivation.

Table 46. Crop wise yield and economics of tuber crops

Crops/Other components	Area (ha)	Yield (kg)	Gross Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C ratio	Employment generation (Man-days)
Yam	0.05	1050	15750	7100	8650	2.22	33
Sweet potato	0.06	780	11700	4000	7700	2.93	16
Yam bean	0.04	540	8100	2550	5550	3.18	12
Elephant foot yam	0.03	780	11700	5000	6700	2.34	20
Colocasia	0.01	245	3675	1500	2175	2.45	10
Cassava	0.01	180	1800	700	1100	2.57	4
Total	**0.2**		**52725**	**20850**	**31875**	**2.53**	**95**

*Sale price of yam Rs 15/kg, sweet potato Rs 15/kg, yam bean Rs 15/kg, elephant foot yam Rs 15/kg, colocasia Rs 15/kg and cassava Rs 10/kg.

16. CONCLUSION

The results of the demonstrations indicated that tuber crops yield was influenced by the locations. The yield variation of greater yam 22.3-26.2 t/ha, elephant foot yam 20.2-25.0 t/ha, colocasia/taro 14.3-15.8 t/ha, sweet potato 11.6-14.2 t/ha, yam bean 15.4-20.5 t/ha and cassava 15.4-18.3 t/ha were noticed. Tuber crops-based farming system (0.4 ha model) resulted in net return of Rs 120938/0.4 ha with crops and backyard poultry, and Rs 148375/0.4 ha with crops, backyard poultry and goats. Providing small agricultural implements and fencing materials to the tribal farmers reduced drudgery and protected the crops from wild animals. Solar pump set brought more area under irrigation and ensured definite harvest. The income of the tribal farmer is doubled with the inclusion of tuber crops in their cropping/farming system and has sufficient food for household consumption. Thus, food and nutrition security and livelihood improvement are achieved through tuber crops technologies.

17. FUTURE OUTLOOK/RECOMMENDATIONS

The root and tuber crops are climate resilient crops. They have great role to play under changing climate. The root and tuber crops have special niche in Odisha agriculture. With the capacity to survive in wide range of environments, ability to provide staple food to disadvantaged population, nutritious animal feed and potential to provide various home and industrial products, the root and tuber crops can consistently cater to the food and nutritional security of the people. The following measures are useful to promote and popularize the root and tuber crops;

1. Popularization of root and tuber crops as climate resilient and alternate crops for crop diversification
2. Production and distribution of quality planting materials of root and tuber crops and capacity building for scientific way of production to increase productivity and income of the farmers.
3. Government policy support for market regulation to improve root and tuber crops scenario in the country
4. Nutrition and health benefit of root and tuber crops should be educated to the consumers and students through campaigns.
5. There is urgent need to popularize various value-added products from sweet potato and other tuber crops (pasta, noodles, extruded products, chips, snack foods, starch etc.) to the consumers through awareness campaign, kisan melas, exhibitions, leaflets etc.
6. Studies on market assessment for export potential and their exploitations are required.
7. Availability of root and tubers through-out the year for developing value added products by storing in suitable warehouses/ storage go-downs.
8. Entrepreneurship development in root and tuber crops in collaboration with line departments.
9. Encouraging start-ups in root and tuber crops
10. Future of sweet potato and other tuber crops in Odisha lies in its diversified uses in the industrial sector. Cassava and sweet potato starch demand is more in bioethanol and adhesive sector especially in the corrugation, gums and textile industry. It finds good demand in the paper industry also. R & D efforts in modifying starch for meeting the quality standards of these industries have to be strengthened.
11. Strategies to popularize root and tuber crops based integrated product development.

So, it is time to understand, accept and promote the root and tuber crops among the farming and industrial community.

18. REFERENCES

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19. 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