STATUS OF CASSAVA IN INDIA
AN OVERALL VIEW

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FOREWORD

Roots and Tubers have critical roles to play in fulfilling the multifaceted needs of the people contributing to food security and poverty eradication. In this endeavor, research partnership, capacity building and policy support for these crops assume significance. Cassava has phenomenal biological potential. The vision for cassava is that it will spur rural industrial development and raise income for farmers, processors and traders besides satisfying the consumers. A National strategy is therefore called for Cassava- Production- Processing- Marketing continuum in specific agro-ecological zones for which R&D strategies need to be tuned towards higher productivity through biotechnological interventions, farming system studies for various eco-systems, value addition for demand generation and technology transfer for area expansion in non-traditional pockets. A comprehensive documentation on cassava is a foundation for developing plans and actions and this document on status of cassava covers all the spheres from production technologies, value addition, transfer of technologies, demand projections, marketing channels, SWOT analysis and future strategies. It would provide invaluable information for use by the researchers, extension workers, policy workers and planners of our country.

I would like to congratulate Dr. S. Edison, Dr. M. Anantharaman and Dr. T. Srinivas for their commendable efforts in bringing out this technical bulletin.

PIU, NAIP (ICAR), New Delhi
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(Mruthyunjaya)

PREFACE

Tuber crops are the most important food crops of man after cereals and grain legumes. Cassava is considered as the king of tropical tuber crops as it occupies a significant position in the global agricultural economy and trade amongst the tuber crops. Our Country relies heavily on agriculture for food security and economic growth but still faces the challenges of not only to produce adequate food to the growing population but also positioning agriculture in the GDP growth rate. In view of market liberalization and globalarization we have to be competitive, cost effective, forward looking besides being strategic.

To achieve these, a thorough information back up is required in any enterprise. The technical bulletin titled *Status of cassava in India: An overall view* is produced to fulfill this long felt demand. This bulletin starts with an Introduction and history, analysis on the trend in area, production and yield, and describes the production and processing systems, lists out the technologies and its transfer attempts and the impact. The cassava marketing system, demand-supply and SWOT analysis are discussed. The bulletin also focuses on the future strategies of cassava R & D.

The authors are thankful to the Scientists of different research divisions of CTCRI, AICRP (TC), SAGOSERVE, Farmers and Cassava starch and sago entrepreneurs for providing the necessary information required for this document. I hope this document will be helpful to Scientists, Extension personnel and the policy makers in formulating projects and programmes for the benefit of farming community.

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1. Introduction

1.1 History

Cassava (*Manihot esculenta* crantz) also known commonly as Tapioca, continues to be a crop of food security for the millions of people especially in the developing countries of the globe. It is an important alternate source of energy to meet the demands of increasing population. This crop has the potential to produce more food per unit area, capacity to withstand adverse biotic and abiotic stresses and adaptability to the conditions of drought and marginal lands. The crop has been cultivated in India for more than a century. Cassava was introduced into India by the Portuguese when they landed in the Malabar region, presently part of Kerala state during the 17th century, from Brazil. The popularization of the crop in the state of Kerala was attributed to the famous king of Travancore State, Sri Visakham Thirunal by introducing popular varieties from Malaya and other places. Cassava saved the people of erstwhile Travancore province from the clutches of famine during II World war (1939-45) when import of rice from Burma (Myanmar) was stopped and the subsequent times of food scarcity. Cassava was used as substitute to rice (staple) especially by the people of low income strata. With the changing economic conditions and the rise in standard of living of the people, it has become a "side dish" even for the affluent sections of the society.

Maharaja Sree Visakham Thirunal

Hither to acting as a crop of food security, the end uses of cassava saw a sea change with the production of many value added products such as starch, sago etc. Industrial use of cassava started initially with the production of diversified products like starch and sago. During II World war, cassava starch and flour production commenced in Kerala. But later, problems like unsuitable weather conditions for drying of starch and relatively very high labour costs led to the diminishing of the industrial conversion and use of cassava in Kerala state. Consequently area under the crop has come down from 3,00,000 ha in 1970s to 94,300 ha in 2003-04.

In 1943, Mr.Manickam Chettiyar of Salem, Tamil Nadu found cassava flour as a good substitute for American corn flour and marketed at Chennai. Sago production commenced in Tamil Nadu with the technical know-how from Malaysia. By 1945, production of sago and starch increased appreciably. Factors like suitable climate for drying of starch, low labour costs in Tamil Nadu prompted the development of cassava based industries and making it as a commercial crop today. The end of II World war posed a threat to the existence of these industries due to import of these commodities from foreign countries under Open General License (OGL). But successful attempts of sago and starch manufacturers convinced the Govt. and this resulted in banning of the imports and thus saved these industries. Scarcity created due to restriction on imports of sago and starch from Singapore, Malaysia, Indonesia and USA during II World war was also one of the factors for the development of the sago and starch industry in Tamil Nadu. At present there are approximately 800 cassava based industries in Tamil Nadu. Area under the crop has increased to 95,000 ha in 2003-04.

Taking the successful example of Tamil Nadu where cassava has changed itself from food crop to commercial crop, some progressive farmers cum industrialists from East Godavari district of Andhra Pradesh started cultivating and popularising the crop to produce sago as well as chips for export. With a view to develop sago industry with modern technology, the then industrialists (Sri Jami Ramulu, Sri Manyam Surya Narayana Murthy, Sri Alladi Kantaiah and Sri Palacherla Kasulu) collected cassava cuttings from Salem in 1965 and distributed to farmers in East Godavari district for cultivation. Slowly sago industry emerged there as a cottage industry by 1970. The area under cassava has increased from 4 ha in 1960 to 19,450 ha in 2003-04. At present there are 65 cassava based industries functioning in Andhra Pradesh and the area is still increasing.

Cassava is also cultivated in an area of 6,300 ha in north eastern states of Assam and Meghalaya as a food crop and to some extent for the production of sago. The states of Maharashtra and Gujarat have also taken up cultivation in several thousand ha and a few processing industries have also been set up in these states.

1.2 Global Vs Indian Scenario

Of the tropical root and tuber crops, Cassava occupies first position in terms of area and production globally. It is found as staple food for those living in several tropical countries of South America and Africa, for eg.; Brazil, Nigeria, Ghana etc..

Globally cassava is grown in an area of 18.51 million ha producing 202.65 million tonnes with a productivity of 10.95 t/ha. (FAO, 2005). It is grown in 102 countries in the world. African continent occupies first position covering 66.21 per cent of cassava area producing 53.37 per cent of the world cassava as it is a staple in many of the African countries. Even though area is more in Africa, its production is low due to low productivity (8.82 t/ha) which is lower than the world average productivity.

Though rice and wheat form a major part of the staple for Asians, it is to be noted that Asian continent is the second largest in terms of area (19%) and production (29%) of cassava with a productivity of 16.76 t/ha. South America has 13.44 per cent of area producing 16.79 per cent (third rank) of the world production.


Cassava crop

Nigeria is having the largest area under cassava (22.25%) among all the cassava growing countries in the world with an annual output of 38.18 million tonnes. Congo Dem. Rep. occupies second position in cassava area producing 10.00 per cent of the world production. Brazil occupies the third position in terms of area and second rank in terms of production in the world.

All the major cassava growing countries in the Asia continent have the productivity more than the world average productivity. Indonesia, Thailand, Vietnam and India are the major countries growing cassava in Asia. India acquires significance in the global cassava scenario due to its highest productivity in the world (27.92 t/ha.) and cultivated in an area of 240,000 ha producing 6.7 million tonnes. Countries covering more than 85 % of the cassava area and more than 88 % of the world production are presented in Table 1.1 and in Fig 1.1, 1.2 and 1.3.

Table 1.1: *Area, Production and productivity of cassava in major cassava growing countries of the World. (2004)*

Continent	Country	Area (million ha)	% to total	Production (million tonnes)	% to total	Productivity (tonnes/ha)
World	**Total World**	**18.50**	**100.00**	**202.58**	**100.00**	**10.95**
Africa	**Total Africa**	**12.25**	**66.21**	**108.11**	**53.37**	**8.82**
	Nigeria	4.12	22.25	38.18	18.64	9.27
	Congo, Dem Republic of	1.85	10.00	14.95	7.38	8.08
	Mozambique	1.05	5.67	6.15	3.04	5.86
	Ghana	0.78	4.24	9.74	4.81	12.42
	Tanzania, United Rep of	0.66	3.57	6.89	3.4	10.44
	Angola	0.64	3.46	5.60	2.76	8.75
	Uganda	0.41	2.20	5.50	2.72	13.51
	Madagascar	0.35	1.91	2.19	1.08	6.21
	Côte d'Ivoire	0.30	1.62	1.50	0.74	5.00
	Benin	0.30	1.62	4.00	1.97	13.33
	Central African Republic	0.19	1.03	0.56	0.28	2.96
Asia	**Total Asia**	**3.52**	**19.00**	**58.92**	**29.09**	**16.76**
	Indonesia	1.27	6.85	19.26	9.51	15.20
	Thailand	1.05	5.67	20.40	10.07	19.43
	Vietnam	0.38	2.07	5.69	2.81	14.83
	Sri Lanka	0.26	0.14	0.23	0.11	8.64
	China	0.25	1.35	4.20	2.07	16.80
	India	0.24	1.30	6.70	3.31	27.92
	Philippines	0.21	1.11	1.64	0.81	7.99
	Malaysia	0.04	0.22	0.43	0.21	10.49
South America	**Total South America**	**2.49**	**13.44**	**34.02**	**16.79**	**13.67**
	Brazil	1.77	9.58	24.04	11.87	13.56

Source: www.fao.org
Note: Figures in parentheses indicate percentage to the world figures.
Countries covering more than 85 % of area and 88 % of the production in the World are given in Table.

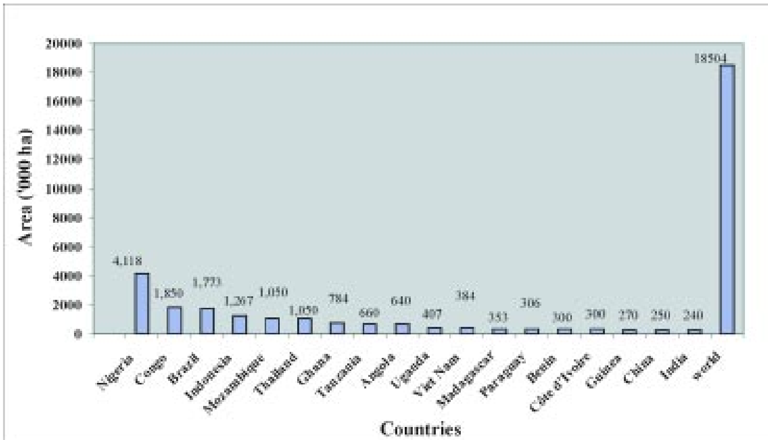


Fig. 1.1 Major cassava growing countries (2004)

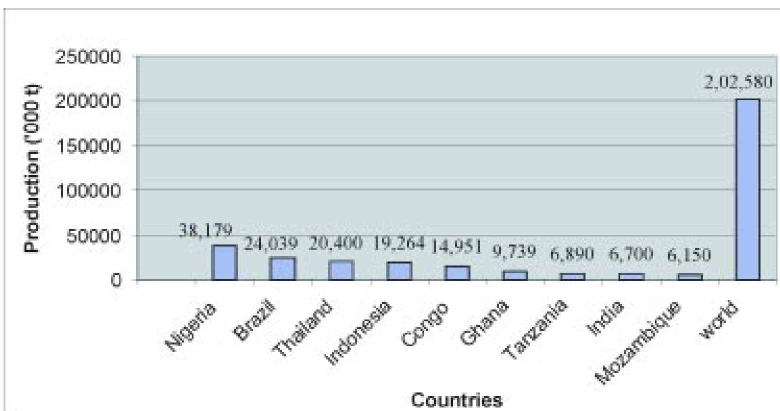


Fig. 1.2. Major cassava producing countries (2004)

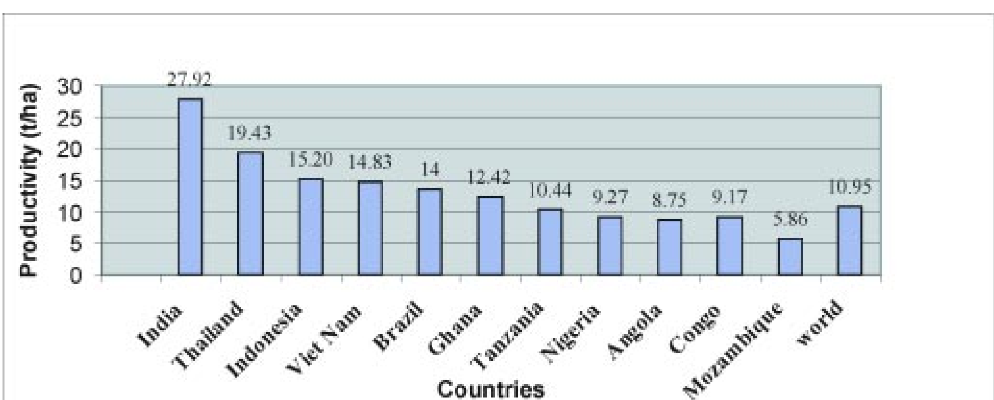


Fig. 1.3. Productivity of cassava in major growing countries (2004)

According to FAO classification, Root and tuber crops form staple diet for three per cent of the global population. Cassava is mostly used for human consumption in the African continent and South America. Industrial utilization of cassava is prominent in Thailand, Indonesia, Vietnam, India in the form of starch, sago, dried chips, flour etc.

In India, 60-70 per cent of the total cassava production is used commercially to produce sago, starch, dried chips, flour etc. Human consumption of cassava is common in Kerala and in northeastern states like Assam, Meghalaya etc. as raw/cooked tubers and as sago in Gujarat, Maharashtra, West Bengal states.

1.3. Regional concentration of the crop

Cropped area under any crop increases depending on factors like agro industries concentration for which, it acts as a raw material, possibility to produce diverse value added products, market outlets for these products besides favourable climatic factors for its cultivation etc.

Cassava is a crop of the tropics. Although it is cultivated in India in 13 states, it is concentrated in the southern peninsular region of the country and to a certain extent in northeast region of the country. The crop is concentrated in the southern states of Kerala, Tamil Nadu and Andhra Pradesh owing to the favourable climate and efficient utilization. Among the southern states, Kerala has a major share in area (1.04 lakh ha) under cassava (43.33 of % of cassava area in India) and the maximum production here goes for human consumption. Tamil Nadu has an area of 95,000 ha (40 % of the total area under cassava in India) and 60 per cent of cassava produced is utilized industrially to produce starch, sago and other value added products. Andhra Pradesh has 8.1% of the cassava area and is utilized exclusively for industrial purposes. The remaining area of cassava is concentrated in the northeast region of the country.

1.4. Utilization pattern of cassava

Cassava finds a place in the home front as well as in the industrial front. In the home front, it is consumed as cooked/baked tubers in culinary preparations and in making pappads. In Kerala, the maximum production goes for human consumption.

Cassava and fish when cooked and consumed together forms a good combination of dietary carbohydrate and protein. Nowadays cassava dishes are seen in big hotels and restaurants. In a limited quantity it is consumed as baked tubers in Tamil Nadu and Andhra Pradesh during harvesting season. Cassava fried chips is another form of utilization observed in Tamil Nadu and Kerala at cottage industries level.

In the industrial front it has wide applications. Many value added products are prepared from cassava viz., starch, sago, flour, chips etc. Cassava starch is having wide industrial applications. It is used in textile industries as sizing agent, in pharmaceutical industries, making adhesives, dextrin manufacturing, paper industry, laundry and in many fast food preparations. A sizeable quantity of cassava produced in Tamil Nadu and Andhra Pradesh is processed in the industrial sector.

Flour is made from cassava dried chips and this finds applications in gum industry, in making Kumkum (Vermillion) and in making colours applied to faces, during celebrations, festivals etc. Thippi (Starch and sago industries fibrous waste) and Peel (Waste from chip industries) are used as an ingredient in poultry and cattle feed preparations. The utilization pattern of cassava in India is shown in Fig. 1.4

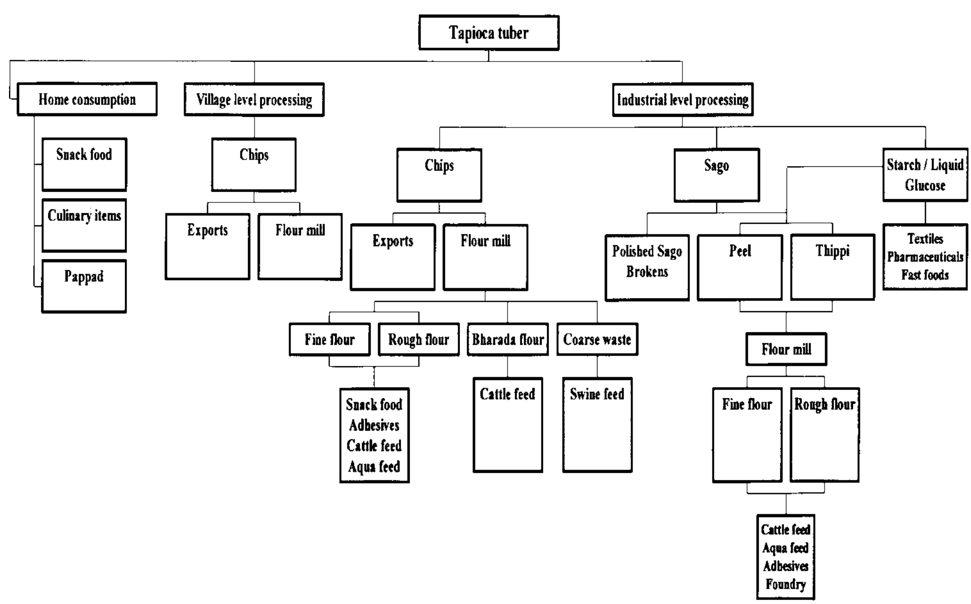


Fig. 1.4. Utilization pattern of cassava in India

2. Spatio-temporal changes in area, production and productivity of cassava in India

Though cassava is grown in about 101 countries, it is encouraging that India ranks first in the world for productivity of cassava with 27.92 t/ha as against the world average 10.76 t/ha. However, India ranks fourth in Asia and 14th in the world for area and third in Asia and 7th in the world for the production of cassava roots. However India accounts for just 1.30% of area.

Although cassava is cultivated in India in 13 states, major production is from the southern states of Kerala, Tamil Nadu and Andhra Pradesh. The area and production figures from 1967-68 to 2001-02 are presented in Table 2.1.

Though Andhra Pradesh accounted for 1.0 per cent of area during 1967-68 and the area increased to 7.5 per cent in 2001-02; and the corresponding figures for production were 0.3 per cent and 5.42 per cent respectively and productivity increased from 3.6 to 20.0 t/ha for the same period. A similar increase was observed for Tamil Nadu which accounted for 12.5 per cent of area and 9.0 per cent of production in 1967-68, increased to 42.5 per cent and 58.74 per cent respectively during 2001-02. Productivity of cassava in Tamil Nadu improved from 9.7 to 37.60 t/ha during the same period. (Productivity of cassava in Tamil Nadu 46.3 t/ha appears to be on the higher side in 1996-97) Though Kerala accounted for 85.7 per cent of area and 90.4 per cent of production of cassava in India during 1967-68, the values declined to 45.5 per cent and 37.9 per cent during 2001-02 but productivity increased from 14.1 to 22.6 t/ha. Though the area under cassava in India had declined during the reference period, the productivity improved from 13.4 to 27.92 t/ha only because of four-fold increase in the productivity of cassava in Tamil Nadu.

The time series data on area, production and productivity of cassava in India for the crop years from 1967-68 to 2001-02 were categorized into five phases based on the values of coefficient of determination of the exponential trend lines. The reference period was divided into five phases namely Phase I - 1967-68 to 1976-77, Phase II – 1976-77 to 1985-86, Phase III – 1985-86 to 1996-97, Phase IV - 1996-97 to 2001-02 and Phase V – 1967-68 to 2001-02. The compound growth rates (%) for cassava growing states are presented in Table 2.2.

Table 2.1. *Area, production and productivity of cassava in India*

States	1967-68	(%)	1976-77	(%)	1986-87	(%)	1996-97	(%)	2001-02	(%)
					Area ('000ha)					
Kerala	297.6	85.7	323.3	84.2	146.95	71.5	142	54.45	109.3	45.5
Tamil Nadu	43.4	12.5	48	12.5	33.8	16. 5	65.7	25.19	102	42.5
Andhra Pradesh	3.4	1	9	2.3	12.5	6.1	22	8.44	17.7	7.5
Meghalaya					4	2	3.9	1.5	4	1.66
Assam	2.1	0.6	1.3	0.3	1.77	0.9	2.4	0.92	2.9	1.21
Karnataka	0.6	0.2	1.2	0.3	1.5	0.7	0.9	0.35	0.9	0.37
Other states			1	0.3	5	2.4	23.9	9.16	2.1	0.87
ALL INDIA	347.1		383.8		205.52		260.8		239.6	100
					Production ('000t)					
	1967-68	**(%)**	**1976-77**	**%**	**1986-87**	**%**	**1996-97**	**%**	**2001-02**	**(%)**
Tamil Nadu	419.4	9	1128.2	17.7	913.4	25.6	3043.2	51.86	3834.6	58.74
Kerala	4198.4	90.4	5125.5	80.5	2576.1	72.1	2588.3	44.11	2471.8	37.9
Andhra Pradesh	12.2	0.3	74.1	1.2	15.2	0.4	174.5	2.97	353.9	5.42
Meghalaya					23.3	0.7	21.5	0.37	20.6	0.32
Assam	9.6	0.2	5.4	0.1	7.5	0.2	11.5	0.2	13.7	0.21
Karnataka	4.1	0.1	16.6	0.3	14.6	0.4	7.1	0.12	6.9	0.11
Other states			14.3	0.2	24.45	0.7	22.2	0.38	18.7	0.29
ALL INDIA	4643.7		6364.1		3574.55		5868.3		6528.6	100
					Productivity (t/ha)					
	1967-68		**1976-77**		**1986-87**		**1996-97**		**2001-02**	
Tamil Nadu	9.66		23.5		27.02		46.32		37.59	
Kerala	14.11		15.85		17.53		18.23		22.61	
Andhra Pradesh	3.59		8.23		1.22		7.93		20	
Karnataka	6.83		13.83		9.73		7.89		7.67	
Meghalaya	5.83		5.51		5.15					
Assam	4.57		4.15		4.24		4.79		4.72	
ALL INDIA	13.38		16.58		17.39		22.5		27.25	

Source: Agriculture, Centre for Monitoring Indian Economy, 2005

Table 2.2. *Compound Growth Rate (%) for cassava in India*

State	1967-68 to 76-77	1976-77 to 85-86	1985-86 to 96-97	1996-97 to 2001-02	1967-68 to 2001-02
			AREA		
Andhra Pradesh	5.95 **	2.04 *	2.29 **	-2.12ns	4.95*-
Assam	-2.44 ns	3.82 **	0.69 ns	-0.67ns	3.22*
Karnataka	3.60 **	0.49 ns	-2.02 **	-2.12ns	0.52ns
Kerala	0.51 **	-1.75 **	-1.59 **	-2.52*	-3.69*
Meghalaya	-	3.26 **	-0.36 ns	0.21ns	0.65ns
Tamil Nadu	0.63 ns	-1.53 *	3.34 **	4.18*	2.38*
ALL INDIA	0.62 **	-1.37 **	-0.10**	0.16ns	-1.69*
			PRODUCTION		
Andhra Pradesh	11.19 **	-1.52 *	6.09 *	-2.35ns	7.58*
Assam	-2.75 ns	4.04 **	1.09 *	3.25*	4.87*
Karnataka	6.56 **	-0.93 ns	-2.95 **	2.13ns	-0.68ns
Kerala	1.38 *	-1.20 *	-1.02 **	-1.74ns	-2.48*
Meghalaya	-	3.72 **	-0.35 ns	0.45*	4.20*
Tamil Nadu	4.28 **	-0.66 ns	5.07 **	5.65*	6.42*
ALL INDIA	1.84 **	-1.05 *	1.39 **	2.31ns	0.23ns
			PRODUCTIVITY		
Andhra Pradesh	4.94 **	-3.25 **	3.72 ns	-0.23ns	2.57*
Assam	-0.31 ns	0.22 ns	0.39 **	3.98*	1.61*
Karnataka	2.84 *	-1.41 *	-0.95 **	4.35*	-0.15ns
Kerala	0.87 ns	0.56 ns	0.58 **	0.79ns	1.26*
Meghalaya	-	0.45 ns	0.014ns	0.23ns	3.52*
Tamil Nadu	3.63 **	0.89 ns	1.68 **	1.41ns	3.94*
ALL INDIA	1.22 **	0.32 ns	1.49 **	2.18*	1.93*

*** - significant at 1%* *ns – Not significant statistically*

** - significant at 5%*

The analysis of the data revealed positive significant CGR% for area, production and productivity of cassava during the first period. Area under cassava registered a significantly negative CGR% during the second and third period resulting in negative CGR% for the whole reference period, while production had negative value but not significant. This was due to the positive growth rate in productivity throughout the reference period. A perusal of the data for all India revealed that area recorded –0.78% compound growth rate (CGR) while that of productivity was +0.75%, both being statistically significant. Though production of cassava in India revealed a declining trend, this was not statistically significant. This is mainly due to the significant declining trend in area and production of cassava in Kerala since 1975-76, despite the positive growth rate in productivity during the reference periods.

The CGR% for area for the three periods were +0.62, -1.37 and –0.10 respectively and were statistically significant. It is a great solace to note that the magnitude of area decline in the third phase is not as much as second phase, indicating there is a probability of area stabilization. The corresponding values for productivity were 1.22, 0.32 and 1.49 and were statistically significant for I and III periods. The declining trend in the second and third periods for area had resulted in the declining trend in the production of cassava in India. The positive trends for productivity had its effect on production and resulting in a negligible decline in production, which is however non-significant. Improving the yield potential of cassava in other states where it is grown for industrial use may stabilize the production of cassava in India.

The positive CGR of the cassava area in India was not statistically significant during the period IV (0.16) indicating the fact that the cassava area in India is in the stabilization phase. The corresponding figures for production and productivity were 2.31 and 2.18 respectively. Positive and significant growth was observed in the productivity of cassava while it was not significant in the CGR of production in India. The increasing trend in the productivity of cassava enabled to stabilize cassava area and production in India.

In the Period V, positive and significant growth in the productivity of cassava helped in positive and non-significant growth in its production in spite of the significant decline in the area at 1.69 per cent per annum.

3. Cassava production system

Cassava is cultivated in different production systems of Kerala, Tamil Nadu and Andhra Pradesh. Farmers are cultivating cassava both under irrigated/low land and rainfed/upland conditions as mono crop and as inter crop in coconut, banana, mango, cashew orchards across the country. It is also interesting to note that the vegetables such as cucumber, ridge gourd, cow pea, groundnut etc. are being cultivated as inter crops in cassava. Different cultivation practices are being followed in various states in diversified production cum cropping systems.

Upland cassava

3.1 Cassava production system in Kerala

Cassava, a crop of food security for people of Kerala until the 19th century is now cultivated in an area of 1.04 lakh ha producing 24.13 lakh tonnes (2002-03). Thiruvananthapuram and Kollam are the major districts in Kerala cultivating cassava. Formerly a crop mainly of upland conditions until the seventies, it started occupying low land areas replacing paddy. It is cultivated under different cropping systems in Kerala i.e., as mono and as inter crop in coconut (in both upland and low land) and banana (low land), rubber (juvenile phase) orchards in upland conditions and as a mixed crop in homestead gardens. It is observed that the area under cassava in upland is declining compared to its earlier scenario in Kerala due to competition from more remunerative plantation crops like rubber and coconut. While in

Lowland cassava

the uplands, cassava is grown as a rainfed crop; in low land, irrigation is provided in some places like Malappuram district. Under low land conditions it was observed that a limited cassava area is replaced by banana and coconut while rubber replaced most of the cassava area in uplands. Eventhough rubber price is fluctuating or even less, farmers still show interest in rubber cultivation due to better income from rubber over cassava. Low land farmers are slowly shifting to cassava replacing rice due to high labour cost.

Cassava as intercrop in coconut

Noorumuttan, Singapore vella, Singapore Azhiyan, Diwan, Aaru masa kappa, Pathinettu, Ullichuvala, Kariyilaporiyan, Karungannan, Ethenchuvala, Mankozhunthan, Narukku, Kandharipadappan, Kalikalan, Venjaramoodan etc. are some of the varieties grown in different districts. In low lands, short duration varieties are grown whereas the long duration varieties are grown in upland conditions. It is common in Kerala to see cassava grown in an area of even one or two cents at every home for using as food/vegetable. Under field conditions, it is cultivated in marginal and small holdings of size ranging between 10 cents to two acres.

Cassava in homesteads

3.1.1. Cultivation practices

1. Land preparation: Cassava under low land conditions is grown on mounds on bunds with irrigation channels. The width of the bunds vary between 450 to 750 cm depending upon the soil type and moisture conditions. It is interesting to note that the low land is used for cultivation of paddy, banana, vegetables and cassava in a cyclic way. If new land is put under cultivation with cassava, channels are prepared. These channels are useful for 9 to 10 seasons/years and these are only to be cleaned and deepened every year. They occupy an area of 0.08 to 0.12 ha in one ha land depending upon the measurements of the channels made. Channel making and/or cleaning is done manually during the planting season. It is a common practice that the farmers mix manures with soil during the mound preparation time, before planting. However, it is also observed that some farmers apply manures in between the rows along with fertilizer application. Nursery raising is not practised in Kerala but is becoming increasingly popular in Andhra Pradesh because of shortage of water.

Cassava planted in bunds under lowland conditions

Replacing old rubber plantations with cassava crop for two to three seasons and replanting rubber in the same area is commonly followed in upland conditions in Kerala. In the newly planted rubber orchard, cassava is cultivated for the first two to three years as inter crop as the canopy of rubber will not permit growth of cassava afterwards and cassava can be phased out judiciously.

2. Planting season: No specific planting season is followed under low land conditions. Planting during the months of March/April and September/October are found to be the relatively popular planting seasons. Under upland conditions, farmers plant cassava with the onset of monsoon i.e., during March-April, June-July and September-October.

Setts of 15 to 20 cm are made and are planted at a spacing of 75 x 90 cm between the rows and between the plants. Setts are generally planted vertically at a depth of 3 to 5 cm with buds pointing upwards. About 10,000 setts are accommodated in one ha.

3. Manures and fertilizers: In general farmers incorporate Farm Yard Manure (FYM) at the time of land preparation in lowland and upland cassava. Some farmers apply

FYM after planting the setts in the main field along with fertilizers. Farmers apply 45:40:65 kg of N, P_2O_5, K_2O under lowland conditions and 60:60:90 kg of N, P_2O_5, K_2O under upland conditions against the recommended dose of 100:50:100 N, P_2O_5, K_2O per ha. N, P_2O_5, K_2O are supplied in the form of factomphos, cassava mixture, muriate of potash, urea, complex fertilizers like 17:17:17, 20:20:0 etc. It was also observed that some farmers apply fertilizers six or seven months after planting.

4.Intercultural Operations: Intercultural operations include weeding and turning the soil upside down around the base of the plant. Generally the first weeding is done 30 to 45 days after planting, second weeding at 5 to 6 months age of the crop and during the latter, soil is tilted so as to cover the base of the plant. Intercultural operations are done manually with the help of a spade.

Interculturing Operation

5.Plant protection: Cassava Mosaic Disease (CMD) is the common disease observed in cassava. Farmers aren't following any measures to control the disease. The whitefly *Bemisia tabaci* is a vector that transmits the disease in field. Its incidence is observed in all the farmers fields and is more intensified in southern districts of Thiruvananthapuram and Kollam.

Among the pests, white fly and scales are common on cassava, though the infestation is not severe. The damage due to rats appears to be more on cassava tubers in both low land and upland conditions and the farmers apply Celphos tablets to control the rat.

CMD in Field

6.Irrigation: Under low land conditions, irrigation is given only during initial stages of planting; irrigation is given four to five times during the first fortnight after planting. In some locations in upland conditions, farmers take up pot watering to the cassava plants during initial days when planted during March-April.

7.Harvesting: Two methods are followed in harvesting cassava in Kerala.

a. Harvesting by farmer himself: Farmers harvest an area of 2 to 3 cents every day. Tubers are collected and taken to the nearby market for selling. This process continues for 10 to 15 days depending on the area cultivated by farmer.

b. By Contract merchant: Contract merchants purchase cassava grown by farmer and the tubers are valued based on random observation of tubers from plants in the field. If the farmer is satisfied by the value offered, crop is sold to the merchant. Expenditure on harvesting, collecting, loading and transportation is borne by the contract merchant. In the case of cassava grown in the homestead gardens or in small pockets, staggered harvesting is done to meet the food requirement of the farm families.

8. Storage of planting material: Healthy planting material is collected and stored vertically and then covered with coconut leaves. It is stored for a maximum of two months before next planting. Planting material loss due to drying, insect attack etc. is less than 10 per cent as the duration of storage is very short. The stored planting material is not given any prophylactic plant protection treatment.

However, in Kollam district, the storage method is little different from the normal practice. Farmers remove the bottom stump portion and put the stems in the soil regularly moistened with water. They are covered with coconut leaves. During planting time, farmers avoid one foot length stem from bottom and top while making setts as the buds in such portions would have germinated or become dry.

Storage of planting material

3.1.2 Cost of cultivation of cassava in Kerala

A study conducted in 2000-01 indicated that a gross cost (Cost C) of Rs.55,742.31 was incurred for cultivation of one ha of cassava under low land production system where as in the up land production system, it was only Rs.35,823.07. The difference in the gross cost of cultivation between the two systems was due to high rental value of land in low land conditions. Imputed value of family labour was estimated to be higher in low land compared to upland production system. Expenditure on labour was more in low land cassava than up land cassava due to high labour involvement for irrigation and intercultural operations. It is also interesting to observe that the farmers were applying more manures and fertilizers in low land cassava than in up land cassava.

On an average farmers are getting 30.88 tonnes of tubers per ha in low land and 23.88 tonnes in up land.

It was estimated that a gross income of Rs.93,189 was obtained from low land cassava cultivation. Even though net income was less in low land over upland production system of cassava, Farm Business Income (FBI) was higher in low land (Rs.66,522.37) over up land (Rs.50,771.20) indicating the profitability of cassava farming under low land conditions. Income due to family labour was observed to be almost same in both the production systems. Farm investment income was more in low land cassava than from up land cassava. Cassava cultivation generates 214 and 136 labour days in lowland and upland production systems respectively.

3.2 Cassava production system in Tamil Nadu

Tamil Nadu occupies second position in terms of area and production of cassava in India and its productivity is the highest in the world. It is cultivated both under irrigated and rainfed conditions. Sixty per cent of the crop is grown under irrigated conditions in Salem, Erode, Dharmapuri and Namakkal districts while forty per cent of the crop is cultivated as rainfed crop in these districts. However the cassava area in Kanyakumari district is mostly cultivated under rainfed conditions and it accounts for nearly 12 per cent of area.

Paddy, sugarcane, turmeric and vegetables are the major crops grown under irrigated conditions in the tracts where cassava is cultivated. Groundnut, Black gram, Bengal gram, Grain Sorghum (Jowar), Fodder Sorghum, Pearl Millet (Bajra), Finger Millet (Ragi) are the crops under rainfed conditions.

Cassava is cultivated both as mono crop as well as inter crop. It is found as intercrop in coconut orchards. Black gram, bengal gram, tomato, onion are raised as intercrops in Cassava. Cassava is rotated with Paddy and Turmeric under irrigated conditions.

Two predominant cassava varieties viz., H-226 and H-165 released from CTCRI are cultivated in Tamil Nadu since 1976 and these occupy more than 70 per cent of area. In addition Mulluvadi, Kumkum Rose, Burma, CO2 are also seen cultivated in many areas recently. More than ninety per cent of cassava produced is for industrial use and grown largely by marginal, small and medium size farmers. In the industrial belt of Salem, large farmers also cultivate this crop.

3.2.1 Cultivation Practices

1. Land preparation: Land where cassava is cultivated are mostly red and black soils. Land preparation is done using bullock and tractor ploughs. Land is ploughed 5 to 6 times on an average either with tractor or bullock ploughs 15-20 days before planting. Before the fourth ploughing, grass and other weeds are removed using manual labour. Manures are broadcast before the last plough in the field. Ridges and furrows or beds and channels are then made before planting.

Planting of cassava setts under irrigated conditions

2. Nursery: Nursery is raised for the crop grown under irrigated conditions. Nursery raising is in practice in Salem, Erode and Namakkal districts only. However in other districts, only direct planting is observed. Setts are prepared using a local equipment "Kuchi cutter" into pieces of six inches length. Very few farmers adopt the sett treatment for controlling scales, mealy bugs etc. with chemicals during nursery stage. Setts are planted on raised beds at a closer spacing and are sprinkled with water and then covered with palm leaves. Water is given to the setts depending on the atmospheric temperature at an interval of 4-5 days till the setts are ready for transplanting. Setts are transplanted in 15 to 20 days after the emergence of first leaf from the stem. Nursery is raised in an area of 10 to 13.5 sq.m sufficient to transplant in one ha of main field.

Planting setts using Kuchi cutter

3. Transplanting: Rooted setts are planted in the main field at a spacing of either 75 x 75 or 90 x 90 cm between the rows and between the plants. Planting the setts along the ridges is also observed. Setts are planted vertically at a depth of 7 to 8 cm.

4. Planting season: Under irrigated conditions, crop is planted during December to February while it is planted in July - September as rainfed crop.

5. Manures and fertilizers: Farmers incorporate FYM before last ploughing @ 12.5 to 25 t ha^{-1}. When cassava is grown under irrigated conditions after paddy, farmers do not apply FYM.

Fertilizers *viz*., diammonium phosphate, single super phosphate, muriate of potash and complex fertilizers are applied by the farmers. Fertilizer is applied in two to three split doses as basal or top applications after weeding the crop. Farmers apply fertilizers indiscriminately both under irrigated and rainfed conditions. Fertilizers are applied after 2 to 3 months of transplanting in the main field at an interval of 15 to 20 days. N, P_2O_5, K_2O are applied @ 65 : 100 : 170 kg ha^{-1} under irrigated conditions and 25 : 25 : 150 kg ha^{-1} under rainfed conditions.

6. Intercultural operations: On an average seven to eight weedings are done in irrigated cassava and four to five weedings in rainfed grown cassava. Very few farmers apply weedicides and this may be due to high cost of weedicides, lack of knowledge on time and type of weedicides to be applied and also due to cheap availability of labourers for manual weeding. During third weeding, earthing up is also done and mostly women labourers are employed for this operation. Weeding and inter cultural operations are carried out during 15, 30, 50, 70, 115, 145, 175 days after planting in the main field.

7. Irrigation: On an average, 15 to 16 irrigations are given during the crop growth depending upon the availability of soil moisture. Irrigation is given immediately after transplanting/planting, within a week after planting and from then onwards at 10 days interval for five months. Irrigation channels are made at the time of land preparation. Ground water is the major source of irrigation.

Cassava field being given the first irrigation

8. Pests and diseases: Among the diseases, CMD and tuber rot are the major diseases. As such farmers do not adopt any control measures for these diseases. Some farmers apply Bavistin. Recently, Spiralling white fly has become an important insect attacking the crop.

9. Harvesting: Before harvesting, irrigation is given for the easy lifting of tubers. Crop is harvested using contract labourers. On an average irrigated crop is yielding 38 t ha^{-1} while under rainfed conditions, yield ranges from 20 to 25 t ha^{-1}. Depending on the variety planted, crop is harvested from 8^{th} month.

10. Storage of planting material: Healthy planting materials are stored under shade vertically for a maximum period of 3 months. No chemical treatment is given to the stored planting material. It was told that the planting material loss may be up to a maximum of ten per cent during storage. Planting materials are covered with palm leaves.

3.2.2 Cost of cultivation of cassava in Tamil Nadu

Cassava is grown in irrigated and rainfed production systems in Tamil Nadu. The survey carried out in 2000-01 indicated that the cost of cultivation was Rs. 50,636.92 /ha under irrigated conditions whereas in rainfed conditions it was Rs.32,174.09 as gross cost. Labour cost was more when cassava is grown under irrigated conditions than in rainfed. Labour expenditure is also maximum under irrigated conditions due to high incidence of weeds. Rental value of land is also higher in irrigated lands. Family labour involvement was observed to be more under irrigated production system.

On an average, the farmers get 26.43 tonnes of tubers per ha and selling at an average rate of Rs.2.23 per kg, leads to a gross income of Rs.58,875.81 from one ha of cassava. It may be noted that average yield in Tamil Nadu was 37.6 t/ha according to CMIE (2005). However it was observed that farmers could get only 26 t/ha in the surveyed areas. Even though the net income was less in irrigated (Rs.8,238.89) over rainfed (Rs.14,529.79) system, the farm business income was higher in irrigated (Rs.25,208.92) over rainfed (Rs.22,395.07) indicating the overall profitability of cassava farming under irrigated conditions. Farm investment income was more from irrigated cassava compared to rainfed cassava.

Cassava cultivation generates 332 and 221 labour days in irrigated and rainfed production systems respectively.

3.3 Cassava production system in Andhra Pradesh

Cassava is cultivated as a rainfed crop in Andhra Pradesh. Around 8.4 per cent (21,500 ha) of the total area of cassava in India is in Andhra Pradesh producing 1,66,100 tonnes of tubers (2000-01). East Godavari district has a lion share in area and production of cassava (more than 90% area and production) followed by the agency areas of Srikakulam, Vijayanagaram and Visakhapatnam districts. Now it is under cultivation in Peddapuram, Gandepalli, Jaggampet, Sankhavaram, Kirlampudi, Addateegala, Rajavommangi, Maredumilli and Raja Nagaram mandals of East Godavari district. Farmers cultivate cassava both as mono crop as well as intercrop with supplementary irrigation only in Kirlampudi mandal of the district. It is cultivated in mango, cashew and coconut orchards during their pre-bearing period. Ridge gourd and cucumber are grown as intercrops in cassava in Kirlampudi mandal.

3.3.1 Cultivation practices

1. Nursery preparation: As the rainfall is less in this district (average annual rainfall is 1053.8 mm), the local practice is to raise a nursery of cassava setts and the sprouted setts are planted in the main field to make sure the establishment of the setts.

Cassava nursery preparation

Nursery is raised in an elevated bed near the main field. The raising of nursery and transplanting in the main field is completed by June. Setts of 6″ length are prepared from the selected healthy planting material with the help of a sharp knife or using vegetable cutter called 'Kattipeeta'. Farmers are not taking much care to make the edges smooth and circular. No sett treatment is practised by farmers before planting in the nursery. Setts are planted vertically in the nursery at a very closer spacing. A nursery area of 20′ x 10′ is sufficient to transplant one ha. Care is taken to maintain sufficient moisture in the nursery immediately after planting the setts in the nursery. Then nursery beds are covered with palmyrah leaves to protect the setts from the scorching sun. Nursery is irrigated in alternate days depending on the prevailing climatic conditions. Setts are transplanted in the main field within 8-10 days of raising nursery. Nursery is retained for a maximum period of 20 days. If rain is delayed, a new nursery is made and transplanting is done with the new planting material. Neither fertilizer application nor plant protection measure is adapted during nursery stage. Top 1′ and bottom stump portion of the stem is removed while making setts. A small area of nursery is also retained after transplanting to use them for possible gap filling.

2. Land preparation: Land is prepared either by tractor ploughing or by bullock ploughing done two to four times. Farm yard manure (FYM) @ 4 to 25 cart loads per ha is incorporated in the field at the time of ploughing and the farmers apply it at the base of the plant during early stages of crop growth. Large quantities of FYM is applied especially when intercrops are grown in cassava.

3. Planting Season: It is generally completed in June month unless delayed by monsoon.

4.Varieties grown: It is observed that the major area under cassava in East Godavari district is covered by H-165 locally called as Kerala. H-226 or Gulabi variety is also grown to a limited extent. It was told that in addition to these two hybrids, one local variety called "Peddapuram local" or "Bombay" is also under cultivation in certain pockets of the district. The major complaint by farmers is that yields are deteriorating year after year due to the continuous usage of same planting material and non-availability of new varieties. Farmers and millers are interested in short duration, high starchy and high yielding varieties.


Cassava variety H-165 grown in Andhra Pradesh

5.Transplanting: Rooted setts of 8-10 days age from nursery bed are transplanted in the main field at a spacing of 110 x110 cms at a depth of 2" in the soil. This spacing is adapted to facilitate the operation of 'Gorru', a local implement used for intercultural operations. Transplanting is done immediately after rain If rain is delayed, some farmers are practising a method in which they pour small quantity of water where the cuttings are to be planted, then plant the rooted cuttings and cover with soil. This helps in establishment of the plant even when rains are delayed for one or two days after planting. At least 10-15 labourers are required for transplanting one ha area. On an average, 8,300 plants are planted in one ha land.

6. Fertilizer application: Farmers apply fertilizers indiscriminately and especially large quantities of nitrogenous fertilizer. Fertilizers are applied 4-5 times at 20, 45, 60, 90 and 120 days after planting. Farmers are of the opinion that if fertilizers especially urea are applied after every rain, it enhances the crop growth. Urea, DAP, Muriate of Potash and Complex fertilizers like 17:17:17, 28:28:0 are the common fertilizers applied by farmers. Against the recommended dosage of 60:60:60 kg NPK per ha, farmers are applying 100:57:47 kg NPK per ha. Phosphatic fertilizers are applied as top dressing much against the recommendation of its incorporation during last ploughing. Generally fertilizers are applied near the plant in the rows.

7. Intercultural operation: Depending on the weed growth, intercultural operations are carried out after 20,45,60 days after planting. Gorru is the implement used locally for intercultural operations. It is operated between the rows. The soil is loosened around the plant using hand hoes. After every rain, gorru is operated.

Weeding done using Gorru

8. Pests & diseases: Red spider mites infestation is noticed to certain extent in the field conditions besides scales infesting the stored planting material. Cassava mosaic disease (CMD) infection is relatively very low here. As such farmers are not adapting any control measures to overcome the problem unless the infestation is severe. Under severe mite infestation, Rogor is sprayed. Eventhough scale attack was observed on the stored planting material, farmers are not following any control measures. It may also be due to the fact that there is no scarcity of planting material here.

9. Harvesting: Irrespective of the variety grown, crop is harvested between 7^{th} and 8^{th} month of crop age because factories do not purchase tubers harvested after March. Due to early harvest of the tubers, starch content in the tubers is obviously at a lower range. Factory owners are of the opinion that tubers harvested after March have more fiber content and less starch. Plant is uprooted manually and tubers are removed and kept in gunny bags to transport to factories. Generally cassava is harvested on contract basis.

10. Storage of planting material: After harvest, healthy, matured and stout stems are collected and kept horizontally under shade/partial shade of neem, coconut trees in the field itself. Stems along with stumps are stored. Stems are kept horizontally either in circular fashion or in rectangular shape. Farmers are not interested to store the planting material vertically. Farmers opined that roots are produced from the basal portion of the stems stored in vertical position and when such stems are used as planting material in the nursery, root initiation is delayed

Storage of planting materials practised in Andhra Pradesh

by more than 10 days. Another problem in vertical storage is that it is prone to cattle grazing.

Each heap of the planting material is 6′ and above. These bundles are covered with palmyrah leaves to protect from scorching sun. The planting material from one acre cassava crop can be stored in five such bundles. The planting material is stored approximately 4-5 months. It was told that storage loss is more in the monocropped cassava planting material than that of the planting material with intercrops.

11.Intercropping: Ninety per cent of the area under cassava is cultivated as mono crop in Andhra Pradesh. But in certain villages of Kirlampudi mandal of East Godavari district, cucumber and ridge gourd are grown as intercrops in cassava. Intercrops are raised wherever irrigation facilities are available. Farmers are of the opinion that if intercrops are grown in cassava, it is not possible to operate gorru and it reduces the yield of cassava crop. An additional income of Rs. 10,000 /ha is obtained by farmers practising intercropping.

3.3.2 Cost of cultivation of cassava in Andhra Pradesh

Ninety per cent of the cassava area in Andhra Pradesh is under rainfed cultivation and remaining ten per cent is grown with supplementary irrigation (two to three times before harvesting the crop). In the area where supplementary irrigation is given, farmers are growing cucumber and ridge gourd as inter crops during the first three months.

The survey conducted in 2000-01 indicated that Rs.31,332.33 was incurred as gross cost for cultivating cassava under irrigated conditions while it was Rs.24,059.73 under rainfed cassava. Farmers apply more of nitrogenous fertilizers and less of Potassium fertilizers. Labour involvement was more on weeding and irrigation operations over rainfed cassava.

Table 3.1: *Cost concepts and Farm Income Measures of cassava in Kerala, Tamil Nadu and Andhra Pradesh under different production systems.*

(in rupees per ha)

Particulars	Kerala		Tamil Nadu		Andhra Pradesh	
	Low Land	UpLand	Irrigated	Rainfed	Irrigated	Rainfed
Land preparation	7602.63	7431.15	2692.74	3669.54	1820.83	1385.8
Sett making & planting	599.06	598.43	53.76	706.75	877.08	485.31
Transplanting	———	———	577.53	———	———	556
Manure application	937.62	572.57	357.12	304.31	351.05	218.75
Fertiliser application	446.54	349.85	163.31	153.88	333.33	383.53
Plant protection-chemical application	131.4	8.93	44.35	1.72	57.29	43.18
Irrigation	438.25	——-	1398.06	———	1493.88	———
Interculture	4447.2	3956.94	9137.63	5326.72	3212.5	3135.58
Harvesting	4174.13	2602.77	4984.92	3633.62	2255.43	1974.55
Watch & ward	———	———	———	———-	241.67	885.04
Gross labour costs	17827.8	15520.6	19409.4	13796.6	10643.1	9067.69
Planting material	476.48	211.23	1234.27	1201.86	312.5	521.79
Manures	4847.02	5632.71	3626.61	2574.14	3030.42	1586.67
Fertilisers	2836.9	2936.09	3705.35	3830.66	3320.08	2900.4
PP chemicals	125.63	77.8	102.82	6.9	206.94	214.47
Fencing	———	———	——-	——-	——-	39.77
Gross material costs	8286.02	8857.84	8669.06	7613.56	7170.88	5263.1
Land revenue	218.89	69.34	1724.92	1098.28	25.42	14.55
Depreciation	253.7	221.88	3792.4	1768.78	300.94	504.77
Interest on WC	81.06	11.61	71.08	55.46	1645.05	1350.69
Cost A_1	26667.4	24681.3	33666.9	24308.8	19484.4	16200.8
Lease amount	1144.17	0	241.94	991.38	1041.67	1268.94
Cost A_2	27811.6	24681.3	33908.8	25300.2	20526.1	17469.7
Imputed Rental value of owned land	24254.6	8750	10637.1	4155.17	8245	5170.45
Imputed interest on Fixed capital	12.5	2.86	1711.72	1498.76	1498.78	595.68
Cost B	52078.7	33434.2	46257.6	30954.1	30269.8	23235.9
Imputed value of Family labour	3663.59	2388.91	4379.28	1219.97	1062.5	823.86
Cost C	55742.3	35823.1	50636.9	32174.1	31332.3	24059.7
Farm Income Measures:						
Yield (t)	30.88	23.875	26.43	19	19.95	16.63
Price/Kg tubers	3.02	3.16	2.23	2.46	1.7	1.57
Gross Returns	93189.8	75452.5	58875.8	46703.9	33915	26038.2
Net Returns	37447.5	39629.4	8238.89	14529.8	2582.67	1978.45
Farm business income	66522.4	50771.2	25208.9	22395.1	14430.6	9837.39
Owned Farm business income	65378.2	50771.2	24967	21403.7	11087.7	8568.45
Family Labour income	41111.1	42018.3	12618.2	15749.8	3645.17	2802.31
Farm investment income	61714.6	48382.3	20587.7	20183.7	12326.4	7744.59

Source: Srinivas, T. 2004 Economics of cassava cultivation in different production systems in India. Journal of Root crops, 30(1): 50-58

Table 3.2: *Labour days generated in cassava cultivation in different production systems in India.*

Operation	Kerala				Tamil Nadu								Andhra Pradesh							
	Low land		Up land		Irrigated				Rainfed				Irrigated				Rainfed			
	HLD	FLD	HLD	FLD	HLD	FLD	TLD	BLD	HLD	FLD	TLD	BLD	HLD	FLD	TLD	BLD	HLD	FLD	TLD	BLD
Land preparation	93.91	3.97	60.76	2.05	—	—	1.44	0.6	15.86	1.19	0.75	0.8	2.4	—	1.47	—	3.8	0.71	1.88	—
Sett making & planting	4.07	6.07	5.95	3.66	10.49	5.72	—	—	13.7	4.66	—	—	24.29	0.42	—	—	20.59	2.94	—	
Application of manures	9.06	3.64	2.9	1.32	3.73	1.33	—	—	3.63	0.92	—	—	6.48	2.34	—	—	3.58	1.73	—	—
Application of Fertilizers	2.26	3.63	2.44	2.93	3.18	3.16	—	—	2.36	2.91	—	—	5.63	1.01	—	—	5.28	1.31	—	—
Application of Plant protection-chemicals	—	1.09	0.09	0.18	0.23	0.04	—	—	—	0.5	—	—	0.16	—	—	—	0.42	0.09	—	
Interculture	35.22	7.02	25.87	3.22	199.51	12.17	—	—	118.2	8.81	—	—	59.3	—	—	—	42.02	3.96	—	—
Irrigation	3.63	6.83	—	—	15.67	39.69	—	—	—	—	—	—	32.16	2.08	—	—	—	—	—	—
Watch & ward	—	—	—	—	—	—	—	—	—	—	—	—	10.63	—	—	—	40.86	—	—	—
Harvesting	31.87	2.06	20.31	4.7	38.01	—	—	—	39.22	0.8	—	—	42.21	—	—	—	44.2	0.18	—	—
Gross labour days	180.02	34.32	118.33	18.06	270.82	62.1	1.44	0.6	192.97	19.79	0.75	0.8	183.25	5.86	1.47	—	160.76	10.92	1.88	—

HLD: Hired labour days; FLD: Family labour days; TLD: Tractor labour days; BLD: Bullock labour days

Source: Srinivas, T. 2004 Economics of cassava cultivation in different production systems in India. Journal of Root crops 30(1): 50-58

Farmers are getting on an average 19.95 tonnes per ha under irrigated system and 16.63 t /ha under rainfed system. Gross income of Rs.33,915.00 can be obtained by selling tubers at an average price of Rs. 1.70 /kg under irrigated cassava. Farm business income of Rs.14430.61 can be obtained from one ha irrigated cassava. Farm investment income of Rs.12,326.44 can be obtained from irrigated cassava which is higher than obtained from rainfed cassava (Rs.7,744.59).

Cassava cultivation generates 188 and 170 labour days in irrigated and rainfed production systems respectively.

4. Cassava processing system

Though cassava was primarily introduced as food crop in India, two centuries ago, recent efforts on post harvest utilisation technologies for converting them into value added products have changed the status of cassava from a food crop to that of a commercial crop especially in Tamil Nadu and Andhra Pradesh, since 1960s.

Low income group families still consume cassava as a cheap source of carbohydrate. But with growing standards of living, people are changing their food habits and slowly shifting to consumption of cereals replacing cassava. It is estimated that 40% of the total production in Kerala is used for human consumption whereas in Tamil Nadu and Andhra Pradesh only 10-12% is used for the same. Cassava is consumed in the form of baked/cooked tubers, fried chips, across the southern India.

Cassava is also used as animal feed and the practice of *in situ* utilization of cassava in animal feeding is common in the villages of Kerala. Tubers are fed to cattle either in raw form or as dried chips soaked in water. It is also observed that some farmers exclusively grow cassava for feeding cattle. Flour from cassava thippi and peel and *Barada* quality flour are being used as a source of carbohydrate by animal feed industries. But this utilization is facing stiff competition from other carbohydrate sources like de-oiled rice bran (DOB), maize grains, sorghum and other coarse cereals due to the cost factor.

Cassava is used as raw material for a number of processed products such as starch, sago, liquid glucose, chips, flour etc. Modified starch, carboxy methyl starch, cationic starch, oxidized starch and pregelatinised starch are being produced using cassava starch. Dextrins (yellow and white), liquid adhesives, ethanol and sweeteners are other products prepared from cassava starch. Development of starch based biodegradable plastics on industrial scale is also picking up momentum in the country recently.

Cassava chips and flour are other important value addition items from cassava tubers. Chips are used for producing flour which finds its application in adhesives, animal feed industry, in textiles and it is estimated that more than one lakh tonnes of chips are produced from cassava tubers annually in Andhra Pradesh, Tamil Nadu and Kerala.

4.1 Processing practices of value added products by entrepreneurs

1. Cassava chips: Fresh cassava roots can not be normally stored without spoilage for more than a 3 - 4 days after harvest. To overcome this difficulty in the marketing and utilization of cassava and to avoid heavy post – harvest losses, the tubers need to be stored into some form of a dried product with longer storage life. The simplest and the common mode of processing cassava is conversion of tubers into chips. These are two forms of chip making. 1. Sun dried chips. 2. Parboiled chips.

Under the conventional practice, cassava tubers are sliced with the help of hand-knives with or without peeling the outer skin and rind. Chips are then dried in the sun for 3 to 5 days depending upon the weather conditions. Moreover, cassava chips are produced in various forms, sizes and shapes at different places. It is estimated that more than one lakh tonnes of chips are produced in India every year. Chalakudy, Perinthalmanna, Thrissur, Kozhikode in Kerala, Attur in Salem

Parboiled chips - Kerala

Dried Chips - Andhra Pradesh

district of Tamil Nadu and East Godavari district in Andhra Pradesh are the major sun dried chip production centres. Farmers as well as small scale industries are engaged in chip production.

Parboiled chips are produced in Kerala to improve the storage life of chips as well as to protect from insect damage. Tubers are cut into pieces with or without peeling and then put in boiling water for ten to fifteen minutes and then they are sun dried and is mostly used as cattle feed.

2.Cassava flour: Cassava chips are used for the preparation of cassava flour which is consumed in the same manner as rice flour. It is used in the preparation of gums, corrugated box making industries, animal feed preparations etc.

Small scale industries are functioning in Andhra Pradesh, Tamil Nadu and a few in Kerala. Dried cassava chips are grounded in the decicator/pulveriser into powder form and the sieved different size flours. Very fine flour, coarse flour and rough/fibrous waste flour are the different grades in cassava flour. While the very fine flour finds application in food industries, adhesives and textile industries, the coarse flour and rough/fibrous waste flour are used in the cattle and poultry feed mix industries. Thippi and peel flour too are mostly used in animal feed.

Starch bags stored in factory

Cassava starch

3.Cassava starch: Cassava finds its major industrial use in production of starch and is produced by 400 factories in Tamil Nadu and one factory in Andhra Pradesh. It is estimated that 1.5 lakh tonnes of cassava starch is produced in India every year. Different grades of starch viz. Full paste, half paste and 'no paste' are produced. It is estimated that per capita starch consumption in India is 0.6 kg against 6.5 kg in the world. India contributes up to 2% of the world starch production, and cassava starch has a share of about 10 per cent in the

Cassava starch factory in Tamil nadu

world starch production, the other major competitors being corn/maize and potato.

It is observed that textile industry is the major consumer of tapioca starch followed by adhesives, paper, food and pharmaceutical industries.

4. Sago: It is used as a snack food in preparation of porridge and also popular as an infant food. Nearly 400 units are producing sago in Tamil Nadu and 28 factories in Andhra Pradesh. It is estimated that 1.5 lakh tonnes of sago in a 85:15 ratio between Tamil nadu and Andhra Pradesh is produced in our country; Moti dana, medium dana, bada dana and nylon sago are the four different types of sago produced commercially in our country. It is mostly used as a food item in the preparation of snacks, sweets etc.

5.Modified starches: Very few industries in Tamil Nadu (2) and Andhra Pradesh (1) are engaged in manufacturing and marketing of cassava starch derivatives such as corrugated gum starch, carboxy methyl starch, acid modified starch, cationic starch, oxidized starch, pregelatinised starch and cold water soluble starch; however physical modification is yet to make a dent.

6.Dextrins: Few industries in Kerala (4) and number of industries in Tamil Nadu are engaged in producing white and yellow dextrins using cassava starch. These dextrins are used in making adhesives for using in manufacturing paper conversion products.

7.Sweetners: Liquid glucose is manufactured from cassava starch by M/s. Vensa Biotech Ltd., Samalkot, Andhra Pradesh and M/s. Usha-te Biotech Industries Ltd., Cuddlore, Tamil Nadu. M/s. Varalakshmi Starch Industries Ltd., Dharmapuri, Tamil Nadu reportedly manufacture malto dextrins and monosodium glutamate from cassava starch.

Ethanol (2 industries) and starch based bio-degradable plastics (4 firms) are other value added products produced using cassava starch in India, although the viability of these industries are to be confirmed.

4.2 Changes in the utilization pattern over the years

1. As Food

In 1882, immediately after the Royal proclamation about the importance of cassava by His Highness the Maharaja of Travancore for supplementing food grains, there was a slow change in the food habits of the poorer segments of the population in the Princely state of Travancore-Cochin (TC State) in South India. During World war I and II, there was an increased dependence on cassava when rice imports were cut off. But eventually cassava became an important subsidiary food in Kerala, even in normal years. In a National Sample Survey (1977-78), it was observed that the average 30-day cassava consumption per capita was 5.55 kg in rural areas and 2.59 kg in urban areas of Kerala. The utilization pattern of cassava indicated that about 3 million tonnes of cassava were used for human consumption in 1981. Comparatively, the per capita consumption of rice did not vary much between urban and rural areas in Kerala. The 28th round of the National Sample Survey indicated that the per capita consumption of rice was 845 calories in rural areas and 840 calories in urban areas, while for cassava it was 366 calories in rural areas and 190 calories in urban areas of Kerala. A food habit survey conducted by a Operations research group has indicated that the average daily consumption of roots and tubers by adults was 175.03 g , school children, 120.80 g; and pre-school children, 30.90 g. It is estimated that 70% of the total production in Kerala is used for food, whereas in Tamil Nadu and Andhra Pradesh, only 5 to 10 % is used for human consumption.

2.Cassava in feed

In spite of the scientific knowledge generated about the possibilities of utilizing cassava as a carbohydrate supplement in animal feed formulations, the feed manufacturers did not use cassava because of its high cost as compared to other cheap carbohydrate sources like corn/maize. But the practice of *in situ* utilization of cassava

Cassava feed fed to cattle

in cattle feeding still exists in the villages of Kerala. In a survey conducted earlier, 70% of the cassava produced was set apart for consumption/marketing, 17% was used for cattle feed, and 13% was given in kind as food to labourers. Farmers with a land holding of 2.4 ha used 36.6% of their retention for feeding livestock.

3. Cassava in Industry

Cassava is used as a raw material for a number of products such as starch, sago, liquid glucose, dextrin, vitamin C, gums and high fructose syrup.

Various issues of the Indian Textile Bulletin showed that corn starch dominates the starch industry approximately in the ratio of 10:1 for corn and cassava. In 1980 and 1981, cassava starch production was around 10,000 t whereas currently the same is more than 300,000 t including the starch used for the production of sago.

5. Cassava technologies generated

Though cassava was introduced as a food crop to ensure the food security as a substitute for rice during nineteenth century from Brazil, it has projected its status to commercial crop in Tamil Nadu and Andhra Pradesh and this was made possible due to intensive research and development efforts of different R & D organizations. Among them, the noteworthy contributions are from the Central Tuber crops Research Institute (CTCRI) in many ways. Technologies developed in various fields such as development of new varieties, value added products, standardization of agrotechniques, plant protection measures and transfer of technology programmes helped in sustaining the crop in the country with the world's highest productivity. These technologies have been grouped in the following broad categories.

1.Cassava Improvement 2. Cassava Production 3. Cassava Protection 4. Cassava Utilization and 5. Region specific technologies

5.1 Cassava Improvement aspects

Though cassava has been under cultivation in Kerala for over two centuries, improvement work on this crop has lagged behind. A research scheme on cassava was started for the first time in India by Dr. A.Abraham during 1942 and after two years, the Tapioca Research Station was established under the Travancore University (now the University of Kerala) with its headquarters at Thiruvananthapuram and two sub-stations one at Ollukkara (Thrissur Dt.) and another at Thiruvalla (Kottayam Dt.) which functioned up to 1963. The most significant and lasting contribution of the initial phase of cassava research was the development of the Malayan clone, M4 which remains as the choicest table variety even today with unmatched culinary qualities.

CTCRI contributed immensively to cassava development in India

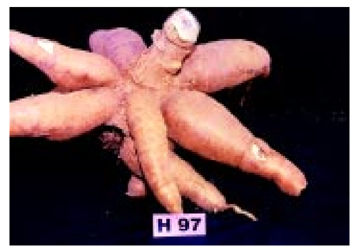
Contributions in the breeding research on cassava in India have been made almost entirely from the CTCRI. Some contributions in the varietal development were also made by Agricultural Universities of the States of Kerala and Tamil Nadu. Besides, the All India Co-ordinated Research Project on Tuber Crops under CTCRI with its fourteen centers, is also helping in cassava improvement by regional testing of varieties at the advanced stage of development.

The CTCRI was established under ICAR during 1963 for conducting research on tropical tuber crops with main emphasis on cassava. An exhaustive collection of the genetic resources of cassava making a total of 1669 (as on October 2006) has been assembled in the Institute and this also includes eight wild relatives such as *M. anomala*, *M., caerulescence*, *M. euprinosa*, *M. flabellifolia*, *M. glaziovii*, *M. grahami*, *M. tristis* and *M. peruviana*. The collections include indigenous (785) as well as exotic accessions (884). The major sources of exotic genetic stocks are from Colombia, Madagascar, Thailand, Nigeria, Malaysia, Uganda, Sri Lanka, Indonesia, Senegal and Gabon and these genetic resources formed the base material in the subsequent breeding achievements. The above genetic stocks are evaluated based on morphological and biochemical descriptors and the promising clones identified for further use as parents for hybridization programme or release as varieties. The various accessions available are either chance seedlings or bud mutants selected for desirable characteristics and maintained by vegetative propagation. Varieties best suited to the location specific requirements are generally adopted and popularized in various traditional and non-traditional cassava growing areas. Besides, the tendency of some farmers to clonally multiply the self-sown seedlings, if it is bestowed with any desirable attributes particularly better tuber characteristics, also lead to the addition of the innumerable land races; these often bear native names for eg: Adukku muttan, Pathinettu, Noorumuttan, Panjara Vella etc. which generally indicate only one of the striking features of the plant.

5.1.1 High yielding varieties

Inter-varietal hybridization between superior varieties and/or selection among recombinants resulted in the isolation and release of the first three hybrids in the world viz., H-97, H-165 and H-226 in cassava from CTCRI in 1971. Even though these hybrids are high yielders, culinary quality was not as good as that of the popular local variety M4. However, they are the most preferred varieties in the neighbouring states as an industrial crop due to high extractable starch content and easy peeling of tubers. Later, two high yielding hybrids with improved culinary quality were released under the names Sree Sahya and Sree Visakham during 1977 and the latter has higher amounts of (466 IU) β-carotene. Important characteristic features of the three hybrids are as follows.

1. H-97 is a hybrid between a local variety 'Manjavella' and a Brazilian seedling selection. The plants are medium tall, branched with light brown emerging leaves. The tubers are conical shaped and stout, yielding 25-35 t ha$^{-1.}$ The tuber flesh is white with 27-29% starch content and matures in 10 months.

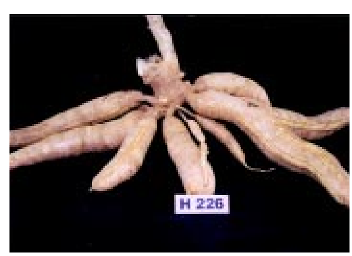


Cassava variety H 97

2. H-165 is a hybrid between two indigenous cultivars viz., 'Chadayamangalam Vella and a clone similar to Kalikalan. The plants are predominantly unbranched with the mature leaves showing a drooping nature. The tubers are relatively short and conical, yielding 33-38 t ha$^{-1.}$ The variety is comparatively early maturing in 8-9 months.

Cassava variety H 165

3. H-226 is a hybrid between a local cultivar 'Etthhakka Karuppan" and the Malayan introduction M4. Plants are tall, occasionally branching and leaves with a characteristic green colour. The tuber yield is 30-35 t ha^{-1} and the crop duration is ten months. Both H-165 and H-226 are the predominant varieties cultivated in Tamil Nadu and Andhra Pradesh for their industrial potential.



Cassava variety H 226

4. Sree Visakham (H 1687) is a hybrid between an indigenous accession and a Madagascar variety S-2312. The female parent is unbranched with light yellow tuber flesh, while the male parent is a heavy yielder with good culinary qualities. Sree

Cassava variety Sree Visakham

Visakham is predominantly a non-branching type and tall having compact tubers with yellow flesh due to high carotene content (466 IU/100 g). Tuber skin is brown and rind is cream in colour. The crop duration is ten months and the tuber yield is 35-38 t ha^{-1} with 25-27% starch.

5. Sree Sahya (H 2304) is a hybrid involving five parents of which two are exotic and three indigenous. Plants are tall, generally non-branching with dark brown and a predominant spiny, stipular mark. The tubers are long necked with light brown skin, cream coloured rind and white flesh. Tuber yield is 35-40 t ha^{-1}. Both Sree Visakham and Sree Sahya are improved varieties for table purpose having better palatability than the former three hybrids and are popular in southern Thiruvananthapuram and western Kanyakumari districts.

Cassava variety Sree Sahya

Cassava variety Sree Rekha

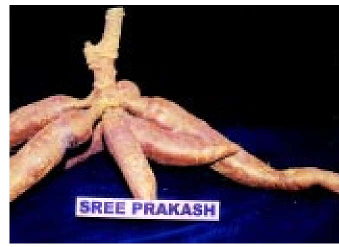
6. Sree Rekha (TCH 1): Top cross hybrid of cassava *viz* TCH 1 was released for general cultivation in Kerala under the name 'Sree Rekha'. The average yield and starch content are 48.0 t ha^{-1} and 28 % respectively. Tubers cook well and give good yields both under upland and lowland conditions.

7. Sree Prabha (TCH 2): Top cross hybrid of cassava *viz* TCH 2 was released for general cultivation in Kerala under the name 'Sree Prabha'. The average yield and starch content are 42.0 t ha^{-1} and 26% respectively. Tubers cook well and give good yields both under upland and lowland conditions.

Cassava variety Sree Prabha

5.1.2. Early maturing varieties

Majority of cultivated cassava varieties take about ten months for maturity and thus occupy the land for a long period. Systematic screening of the germplasm collections has resulted in the identification of three early maturing varieties in cassava which can be harvested at 6-8 months. The early maturing selection 'Sree Prakash' released from CTCRI during 1987 was quickly adopted in paddy based cropping systems in low lands of Kerala state for eg: in Alappuzha district. Later, two more short duration varieties viz. Sree Jaya and Sree Vijaya were also released for this purpose in 1998 and are popular in Kollam and Pathanamthitta districts.



Cassava variety Sree Prakash

1. Sree Prakash is a relatively short statured plant, generally non-branching with high leaf retention. The tubers are medium sized, necked and the tuber yield is 35-40 t ha^{-1}. The duration is 7-8 months. Tubers possess good culinary quality and give a starch content of 29-31%.

Cassava variety Sree Jaya

2. Sree Jaya is a medium tall variety and produces conical tubers and have white flesh. Its duration is 6 months and tuber yield is 26-30 t ha^{-1}. The cooking quality of the tuber is very good and on par with the popular local variety M4.

3. Sree Vijaya is also medium tall and has conical tubers but yellow flesh. The tuber yield is 25-28 t ha^{-1} and duration is 6 months. It has average cooking quality.

5.1.3 Breeding work outside CTCRI

Cassava breeding research is in progress at the State Agricultural Universities of Kerala and Tamil Nadu as well as the Department of Horticulture and Plantation Crops of the Government of Tamil Nadu. The Kerala Agricultural University has released two short duration varieties viz. Nidhi in 1993 and KMC-1 (Vellayani Hraswa) in 1998. Four varieties viz. CO-1, CO-2, CO-3 and CO-4 were also released for general cultivation from Tamil Nadu

Cassava variety CO1

Agricultural University. The Horticulture Department of Tamil Nadu released two varieties, MVD-1 and MVD-2 in 1993. These varieties are yet to make a dent into the cultivator's fields except to a limited extent by CO-2 and MVD-1.

(Information on cassava improvement technologies was provided by Division of Crop Improvement)

5.2 Production technology of cassava

The production technology recommended are as follows

1. Conditions suitable

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

2. Planting season

Plant the setts in April-May (main season) before the onset of south-west monsoon or September-October coinciding with the northeast monsoon. Plant at any time of the year, if grown as an irrigated crop, but December-January planting is better.

3. Methods of planting

Mound method

Follow this in poorly drained soils. Prepare mounds at a height of 25-30 cm.

Ridge method

Follow this in sloppy lands for rainfed crop and in level lands for irrigated crop. Prepare ridges across the slope/along the contour to a height of 25-30 cm.

Flat method

Follow this in level lands having good drainage.

4. Ideal planting material

Select planting materials from mature, healthy stems having 2-3 cm diameter. Discard the woody basal portion and tender top portion of the stem. Prepare setts of 15-20 cm length with a smooth circular cut. Setts prepared from stems stored for 15 days with leaves give better sprouting.

5. Sett planting

Plant the setts vertically (buds upward) to 5 cm depth; avoid inverted planting.

Give 90 x 90 cm spacing for branching /semi-branching types and 75 x 75 cm for non-branching/errect branching type.

Replace the dried up setts with fresh setts of longer size as early as possible.

Raise a nursery from healthy stems. The setts may be planted very close so as to accommodate 400 setts per square metre area. Irrigate the nursery, in case, rains are not received. Rogue out the settlings, showing mosaic infection and uproot apparently symptom free settlings for planting at three weeks stage in the main field. Provide irrigation in the absence of rain.

6. Manuring and interculturing

Incorporate 12.5 tonnes of FYM per ha. Or practice green manuring *in situ*. Apply the following quantities of NPK fertilizer @ 100:50:100 per ha.

7. Fertilizer recommendations

S. No.	Fertilizer	Basal dressing (kg/ha)	Top dressing (kg/ha) 45 – 60 days after planting
1	Urea	110	110
2.	Mussorie Phosphate/Rajphosphate	250	-
3.	Muriate of Potash (M.O.P)	85	85
	or		
1	Urea	110	110
2.	Super Phosphate (Single)	300	-
3.	Muriate of Potash (M.O.P)	85	85
	or		
1	Urea	65	110
2.	Di-Ammonium Phosphate	110	-
3.	Muriate of Potash (M.O.P)	85	85
	or		
1	Urea	-	110
2.	Ammonium Phosphate/Factomphos (20:20)	250	-
3.	Muriate of Potash (M.O.P)	85	85

(For M-4 and local types, apply half the above dose)

P application can be skipped for four years when available P status of the soil is high. Thereafter, a maintenance dose of 50 per cent need be applied.

Retain only two healthy shoots on opposite sides and remove rest of the sprouts at 30 – 45 days after planting. Weed, top dress with fertilizer and then earth up the crop.

A second weeding and earthing up may be given 1-2 months after the first weeding and earthing up.

8. Crop Protection

Cassava is affected by a few serious pests and diseases.

Spider mites occur during dry season from January to May, feed on leaf sap, causing blotching, curling and leaf shedding.

Spray Dimethoate or Monocrotophos 0.05% at monthly intervals starting from January whenever infestation occurs. Spraying water at runoff level on the foliage at 10 days interval is also effective.

Scale insects infest the stems when stacked and occasionally in the field, causing drying. Collect stems free of scale insects.

Store stems in vertical position in shade to prevent multiplication of scale insects.

As prophylactic measure, spray the stems with 0.05% Dimethioate during storage.

9. Cassava mosaic disease

Cassava mosaic disease 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.

Use disease-free planting material.

Grow field-tolerant varieties like H-97, H-165, Sree Visakham and Sree Sahya.

Rogue out infected plants and follow strict field sanitation.

Keep the fields free of self sown cassava plants which may serve as a source of innoculum and thereby help the spread of disease. Prompt disposal of cassava residue is essential.

Tuber rot

Tuber rot is caused by *Phytophthora drechsleri*. Infected tubers show brown colouration of internal tissues, rotten and emit foul smell and unfit for consumption or marketing, causing heavy yield loss.

Tuber rot

Improve drainage.

Remove infected tubers from field and incorporate *Trichoderma viride* in the soil.

10. Harvesting

Harvest the tubers depending upon the maturity of the cultivar.

Stack the stems vertically in well aerated shady places for subsequent planting.

11. Intercropping

Gives an additional net income of Rs. 3000-5000/ha within 3-3 ½ months.

Utilize light, water and nutrients more effectively from the interspaces of cassava.

Control weeds and adds organic matter and nitrogen to the soil.

12. Planting the main crop and intercrop

Select only bushy types of intercrop which mature within 100 days. Plant cassava in the month of May-June at a spacing of 90x90 cm. Dibble the intercrop seeds immediately after planting of cassava. Basal dress cassava as per schedule given for pure stand.

Apply the recommended dose of NPK to the intercrops about 30 days after sowing followed by light interculturing. Top dress cassava immediately after harvest of intercrops with the recommended dose of fertilizers and earth up.

Goundnut intercrop

Cowpea intercrop

Cultivation details of intercrops

Name of intercrop	Cultivar	Duration (days)	Spacing (cm)	No. of rows	Seed rate (kg/ha)	Fertilizer NPK (kg/ha)	Yield (kg/ha)
Groundnut	TMV-2, TMV-7, Pollachi-2	100	30x20	2	40-45 (kernel) (dry pod)	10:20:20	1200
French bean	Contender	70	30x20	2	40	20:30:40	2000
Cowpea (grain)	S=488	90	30x15	2	20	10:15:10	800
Cowpea (vegetable)	B-61 (Arka garima)	65	90x20	1	8	10:15:10	3000

5.2.1 Developing an alternate technology for the production of disease free planting material of cassava through nursery technique

Low availability of quality planting material is a major hindrance in the cultivation of cassava. High yielding varieties released by research stations take several years to reach the end user because of the extreme low multiplication ratio (1:10) in cassava. Another major problem detrimental to cassava cultivation is the sporadic spread of cassava mosaic disease (CMD). The disease is widely spread in all major cassava growing areas in India. It has therefore become quite essential to produce disease free planting materials. Investigation carried out at the Central

Tuber Crops Research Institute, Thiruvananthapuram has revealed that these twin problems could be addressed by a simple agro technique called Minisett technique. A brief on the technique, its potential and feasibility is mentioned below.

Cassava is a clonally propagated crop, in which stakes of 15 to 20 cm are normally used as planting material. A cassava plant with two stems on an average would give 10 stakes or setts of 20 cm length after an year. Hence the multiplication ratio in cassava is only about 1:10. This when planted at a spacing of 90x90 cm would produce about 24,500 stems per ha for subsequent planting. Primarily, mature and disease free stems should be selected. As the name "minisett" signifies, size of setts is reduced to two nodes of about 3 – 5 cm length instead of traditional 15 – 20 cm long setts consisting of about 9 – 12 nodes. Minisetts are made by using small hack-saw with sharp blade in order to ensure round and uniform cut.

Cassava nursery

They are then planted end to end in small furrows made on nursery bed of 1 m width and of convenient length. The nursery bed should be under a shade of about 35 5 and provision for irrigation be made. Preferably sand medium may be used for the nursery bed. Nursery planting is done at very close spacing, taking care that the setts do not touch each other. Frequent and light irrigation need to be given. Minisetts would sprout in a week's time. If any sprout express symptom of CMD, such plants should be immediately destroyed. It would be ideal to spray any systemic insecticide at fortnightly interval against the white fly (*Bemisia tabaci*), which is the vector responsible for spread of CMD. When the minisetts reach three to four leaf stage (about a month), they are ready for transplanting to the main field. The main field should be thoroughly ploughed and brought to a fine tilth. About 12.5 t ha^{-1} of dry FYM is spread in the field followed by preparation of ridges at a spacing of 45 cm. At the time of transplanting there should be sufficient moisture in the field. Minisetts are carefully uprooted from the nursery causing least injury to the root and plant. They are then carefully planted on ridges at a spacing of 45 cm. The plants establish in a week's time.

Fertilizer requirement is 100:50:100 kg ha^{-1}NPK of which N and K could be applied in two equal splits and P as a whole at the first application. The first split application could be done one month after transplanting along with intercultural operation followed by the second, one month later. The plants mature in about 7 – 9 months time depending upon the varietal character. On harvest about 50,000 cassava stems could be obtained. Tuber yield expected is about 40 to 45 t ha^{-1}.

(Information on cassava production technologies was provided by Division of Crop Production)

5.3 Cassava protection technologies

1. Indian Cassava Mosaic Disease (ICMD): ICMD is a major constraint in cassava production. The disease intensity, yield loss assessment, spread and transmission of the disease, varietal reactions, virus purification, identification and characterization of Indian Cassava Mosaic virus (ICMV), serodiagnosis, virus elimination through meristem culture, multiplication of disease free planting material and management of ICMD through integrated methods have been accomplished mostly in CTCRI.

Cassava mosaic disease

- Yield loss varied from 17-42% depending on the varieties and location and the production system.
- Five grade scale for disease indexing was developed
- Indian Cassava Mosaic begomo virus (ICMV) identified as a causative agent of this disease was purified and characterized. Virus particles are bipartite geminate particles having 16-18 nm diameter and possess single stranded DNA as their genome.
- Transmission studies of the disease showed that the virus can be mechanically transmitted to *Nicotiana benthamiana, N. glutinosa, Cucumis sativus, Jatropha strammium* and *Helianthus* sp. It is not transmitted through seeds.

Insect transmission through *Bemisia tabaci* was observed in field condition but not so much successful in glass house condition.

- Two types of spread of ICMD were observed. Primary spread through indiscriminate use of infected planting materials and secondary spread through insect vector *B. tabaci.* Field spread of ICMD varies with different cultivars.
- Degeneration of cassava planting material due to ICMD was recorded. The reduction of growth and tuber yield due to ICMD progressively increased and was proportionate to the increase in the disease spread and the rate of spread and degeneration of cassava varied among the varieties.
- Immunological studies showed that ICMV is serologically related, but distinct from ACMV, based on the ELISA tests with panels of monoclonal antibodies.
- Integrated disease management practices were developed.

Use of disease free planting material, timely rogueing and strict field sanitation can successfully contain the disease. Though no absolute resistance is available in cultivated varieties, improved varieties like M4, H 97, H 165, Sree Visakham and Sree Sahya have good field tolerance. Disease free planting materials can be generated through meristem culture technique. Large scale multiplication of virus-free planting materials of all the released cassava varieties and the popular variety M4 has been successfully undertaken at CTCRI.

2. Tuber rot: Occurrence of this disease in serious proposition was observed in the recent years since 1999 in Salem area of Tamil Nadu. Some of the characteristic features of the disease are,

- Yield loss was up to 40% in the affected areas.
- Pathogen responsible for this disease was identified as *Phytophthora drechsleri.*
- Integrated disease management practices are tested in field and recommended.

3. Brown leaf spot disease: The disease intensity, yield loss, identification of resistant / tolerant lines, cultural and fungicidal control of brown leaf spot disease have been worked out. More than 1000 accessions have been screened and five accessions

Ci. 160, Ci. 373, S-856, H-97 and H-1687 (Sree Visakham) were identified as resistant ones.

Cassava brown leaf spot disease

4. Spider mites of cassava: Four species of spider mites belonging to two distinct groups cause severe damage to the crop. They are *Tetranychus cinnabarinus* Biosd. and *T. neocaledonichus* Andre, infesting the dorsal surface of the leaves and the second group includes *Eutetranychus orientalis* Klein and *Oligonychus biharensis* Hirst., damaging the ventral surface of the leaves. Comprehensive studies have been made on these mites complex covering the distribution, nature and extent of damage, biology and bionomics, ecology, assessment of yield loss, economic threshold, effective control measures, integrated pest management, varietal resistance etc. The yield loss in the range of 17 to 33% under severe natural infestation by mite complex on different varieties in two planting seasons indicated that spider mites are potential enemies of cassava.

Cassava stems infested with spider mites

The accessions Ce-38, Ce-4, Ce-14, Ce-2, Ce-139 and Ce-81 were consistent in their resistance to mite infestation over five years of screening and they (except Ce 14) gave a tuber yield of 22 to 30 t/ha. Resistant accessions (Ce-2, Ce-4, Ce-14, Ce-38 and Ce-139) showed high RWC ranging from 84 to 90%. In susceptible accessions (Ce-162, Ce-163, Ci-36, Ci-200, Ci-224 and M4) the RWC was lower (65 to 78%). A highly significant negative correlation (r = -0.930) was found between RWC and mite density. The population build up is greatly dependent on climatic factors and moisture stress. Rainfall and humidity are negatively correlated while the temperature is positively correlated in the population buildup. Economic control measures are available (spraying Dimethioate/monocrotophos during epidemics at monthly intervals or spraying water at 10 days interval).

5. Scale insect on cassava : *Aonidomytilus albus* Ckll. is an important pest on stems in the field itself. It can be managed by (i) selection of pest free stems and storing as planting material (ii) vertical staking of stems under shade (iii) need based spraying of Dimethioate 0.05%.

6. Storage pests of cassava: Cassava tubers are stored more in the form of chips and flour. During storage about 21 insects were found to infest dry cassava chips/ flour. Among them Arecanut beetle (*Araecerus fasciculatus*), Cigarette beetle (*Lasioderma serricorne*), rice weevil (*Sitophilus oryzae*), red flour beetle (*Tribolium castaneum*), black borer (*Dinoderus minutes* and *D. bifovedatus*), lesser grain borer (*Rhyzopertha dominica*) and almond moth (*Ephestia cautella*) were more prevalent.

An IPM programme to manage the storage pests include the following

- The store should be cleaned before storage
- Dry chips/flour thoroughly before storing
- The moisture content should be below 10%
- Fast drying preferably in oven prolongs storage life.
- Chips can be disinfested by fumigation using 3 to 5 aluminium phosphide tablets (3g wt. of each tablet) per hour. Fumigation should be done in air tight metal bins. Fumigation also can be done in stacks of bags covered by gas proof sheets. Minimum 5 days are required for fumigation after that the residue should be removed and destroyed. Bags used for storing chips should be free from holes. Polythene impregnated jute bags, HDPE woven bags etc can be used. The surface of bags may be treated with safer insecticides like Malathion 0.5%, Fenvulerate 0.3% or Nimbicidin 5%.

Parboiling the chips before drying also reduces infestation. Fermented cassava products are resistant to few insects. Chips containing more cyanogens content (>100 µg/g) are resistant. Keeping the products at low temperature (below 20^{o}C) reduces insect infestation. Heating chips are 60^{o} C for 4 hr or 50^{o} C over night kills all stages of the insect pests. Admixture of granular salt @ 3 g/100 g chips before drying also reduces infestation for six months.

7. Nematodes infesting cassava: A number of exotic and indigenous cassava accessions were found to be resistant to root-knot nematode. Among the cultivars screened, Sree Sahya, Sree Visakham, Sree Prakash and M4 were found to be resistant to the nematode.

Aqueous extracts of cassava leaves, tuber flesh and rind were found to possess nematicidal properties. Infective second stage juveniles of root-knot nematode died, when explored to diluted extracts of the above, within 24 to 48 hrs.

(Information on cassava protection technologies was provided by Division of Crop Protection)

5.4. Cassava utilization

5.4.1. Storage and preservation: Biochemical and microbiological causes of cassava tuber spoilage have been thoroughly investigated and simple low cost technologies have been developed for storage of fresh cassava tubers.

Various conventional packaging materials have been investigated for effective storage of dehydrated cassava products such as starch, chips and flour.

5.4.2. Harvesting and processing equipment: A number of equipments suitable for small holdings and primary processing of tuber crops have been developed to facilitate marketing and utilization of cassava and to avoid heavy post-harvest losses. These include

1. Chipping Machines (Hand-operated, Pedal-operated and Motorised)
2. Cassava harvesting tools (1st order and 2nd order lever types)
3. Hand Peeling device/knife
4. Dryers (Electrical and non-conventional energy based)
5. Mobile starch separation plant
6. Primary rasper for starch extraction

Cassava chipping machine (hand operated)

Cassava chipping machine (pedal operated)

Cassava harvesting tool

5.4.3. Technologies for farm front and cottage industries: Traditionally cassava has been utilized for consumption as vegetable. Technologies have been standardized to produce value added products from the tubers which can be feasible even at cottage industry level. Some such intermediary food products include 1. Yuca Rava 2. Yuca Porridge

Processing techniques have been standardized to eliminate toxicity from cassava to enhance their shelf life as food crops.

Technology for ensiling cassava have been developed to realize the potential of this crop as animal feed. The technology has also been scaled up in plastic silos (200 kg capacity) and underground silos to find its feasibility as a storage technique.

A microbial technique using mixed culture inoculum has been developed to extract starchy flour with modified functional attributes.

Simple low cost technologies have been developed to prepare gums with and without chemical additives.

5.4.4. Technologies for small scale and large scale industries: Manufacturing processes for production of sweeteners such as liquid glucose, fructose syrup, maltose and maltodextrins have been standardized.

Processes have also been developed for production of commodity chemicals such as ethanol, citric acid and monosodium glutamate. A pilot plant to produce commodity chemicals from tuber crop starches has been established comprising of boiler, hydrolyser, filter press, neutralizer, fermenter and distilling column.

Techniques have been developed to modify tuber crops starches into derivatives such as Oxidised starches, Cationic starches, Acid modified starches, Crosslinked starches, Acetylated starches, Carboxymethyl starches and Cold water soluble starch.

Integrated effluent treatment system

An integrated effluent treatment system has been developed for management of toxicity, BOD and COD in the waste waters generated from cassava starch / sago industries and was installed in M/s Selvakumar Sago Factory in Thammampatty, Tamil Nadu during 2000.

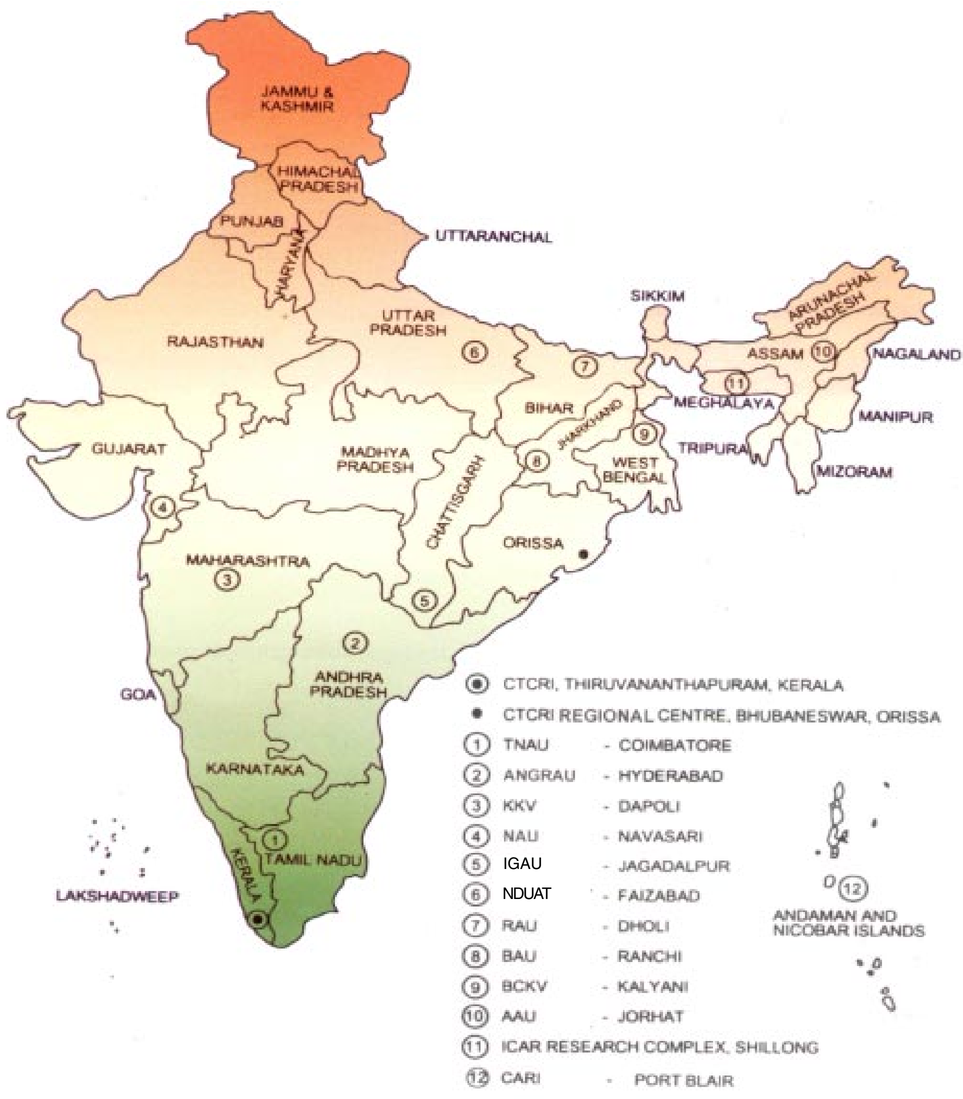
Cassava fried food products

Production Technology for various fried products from cassava flour viz., Cassava/Tapioca pakkavada, Cassava/Tapioca sweet fries, Cassava/Tapioca sweet demons, Cassava/Tapioca salty delight, Cassava/Tapioca salty demons, Cassava/Tapioca nutrichips (with egg), Cassava/Tapioca nutrichips (without egg), Cassava/Tapioca crisps, Cassava/Tapioca hot sticks and Cassava/Tapioca murukku was ready for transfer.

(Information on cassava utilization technologies was provided by Division of Crop Utilization)

5.5. Region specific technologies for cassava

CTCRI, Thiruvananthapuram has been functioning as one of the voluntary centres distributed throughout the country of All India Coordinated Research Project on tropical tuber crops. These centers have been working to develop region specific technologies for tuber crops cultivation and popularization in different areas of the country. Under this Scheme, potential technologies have been exchanged for evaluation and popularization with other coordinating centers of the AICRP in relation to the respective state (s).



AICRP on Tuber Crops

A large number of varieties/cultivars are grown in different regions of the country. An introduction from Malaysia viz. M-4 by the Travancore University in 1940 is still a popular variety for culinary purpose in southern Kerala. Like-wise H-165 and H-226, the hybrid varieties released from CTCRI are the ruling ones in the industrial belt of Tamil Nadu and Andhra Pradesh since 1976. The salient features of the varieties released/recommended during the biennial workshops of the All India Co-ordinated Research Project on Tuber crops for different regions are indicated below.

5.5.1 Salient features of improved varieties of cassava

S. No.	Variety	Name of Organization developed/year of release	Salient features	Average yield (t/ha)
1	CO-1 (ME-7)	Released in 1974 for Tamil Nadu (TNAU, Coimbatore)	A clonal selection from Trichirapalli in Tamil Nadu. Plants are medium tall (1.5 to 2.5 m). Young stems are green. Emerging shot is pink. Number of tubers/plant is 8 to 12 having a length of 0.28 to 0.29 m. Colour of tuber skin is brown, rind colour is creamy and colour of flesh is white. Tolerant to CMD and scale insects. Duration 260-275 days.	30
2	CO-2	Released in 1985 for Tamil Nadu (TNAU, Coimbatore)	A clonal selection from Tiruvarur line. Plants are highly branched. Tuber skin is grey and flesh is white. Duration 260-275 days.	37.5

S. No.	Variety	Name of Organization developed/year of release	Salient features	Average yield (t/ha)
3	H-97	Released in 1971 for Tamil Nadu, Kerala, Karnataka (CTCRI, Thiruvananthapuram)	Plant is medium tall and is non-branching. It is a hybrid of an indigenous cultivar and an exotic selection. Emerging leaf has light sepia colour. Skin is light brown, rind is cream and flesh is white with 27-29% starch. Tolerant to CMD. Duration 260-300 days.	25-35
4	H-165	Released in 1971 for Tamil Nadu, Karnataka and Kerala (CTCRI, Thiruvananthapuram)	Plants are tall and are non branching. It is hybrid from a single cross of two indigenous cultivars. The petiole has pink colour and emerging leaves are light brown. Duration 220-240 days	33-38
5	H-226	Released in 1971 for Tamil Nadu, Karnataka and Kerala (CTCRI, Thiruvananthapuram)	The variety is a cross between M 4 and an indigenous cultivar. Plants are medium tall, mostly non-branching and have leaves with prominent green colour. Tubers are smooth, tuber rind is light purple and flesh is white having a starch content of 28 to 30.5. Preferred by industries, possesses high degree	30-35

S. No.	Variety	Name of Organization developed/year of release	Salient features	Average yield (t/ha)
			of field resistance to mites and scale insects but susceptible to CMD. Duration 260-300 days	
6	H-1687 (Sree Visakham)	Released at National level in 1984 for Assam, Andhra Pradesh, Karnataka, Kerala, Maharashtra, North-Eastern Region and Tamil Nadu. (CTCRI, Thiruvananthapuram)	It is a hybrid developed by crossing an indigenous collection with an exotic collection. It is medium to tall and predominantly non-branching type. New leaves have light brown colour. Number of tubers 8 to 9 per plant. Tubers are conical shaped and compactly arranged. Skin of tuber is brown and flesh is light yellow. Starch percentage is 26 and cooking quality is fair, rich in carotene. Resistant to *Cercospora* and mites. Duration 270-300 days	36-50
7	H-2304 (Sree Sahya)	Released at National level in 1983 for cultivation in Andhra Pradesh, Assam, Karnataka, Kerala, North Easter Region and Tamil Nadu. (CTCRI, Thiruvananthapuram)	It is a hybrid developed by multiple crossing of two indigenous and three exotic collections to have a plant of tall and compact structure with high yield and better quality. Emerging leaves have light sepia colour with purple coloured petiole.	35-40

S. No.	Variety	Name of Organization developed/year of release	Salient features	Average yield (t/ha)
			Tubers are long and cylindrical. Tuber skin is light brown, has got white flesh and post harvest life of 3-4 days. Tolerant to CMD, *Cercospora* and mites. Duration 300-320 days.	
8	S-856 (Sree Prakash)	Recommended in 1987 as a short duration line for the state of Kerala. (CTCRI, Thiruvananthapuram)	The variety is a selection of an indigenous line. The plant is short, non-branching with dark leaves. Tubers are medium, arranged in radial form and shallow bulking type. The variety is highly tolerant to *Cercospora* leaf spot. Starch content is 29 to 31% with fair cooking quality. Duration 210-240 days.	30-40
9	CO-3	Released in 1983 for Tamil Nadu (TNAU, Coimbatore)	It is a branching type. Colour of the skin is dark brown where as, colour of flesh is white. It is tolerant to CMD. Cooking quality is good and is sweet in taste. Flesh has got high starch and low HCN contents. Duration 240-270 days.	40
10	H-119	Proposed for release in 1995 for Tamil Nadu in the 3rd Group Meeting of AICRP. (TNAU, Coimbatore)	Performs well under Coimbatore condition with shorter crop duration ($7^1/_2$ months), higher yield, non-branching nature and	36

S. No.	Variety	Name of Organization developed/year of release	Salient features	Average yield (t/ha)
			better consumer preference. Starch content is 35.2%.	
11	Sree Jaya	Released in 1998 for Kerala	Early maturing variety with good culinary quality. Suitable for low land cultivation as a rotation crop in a paddy based cropping system.	26-30
12	Sree Vijaya	Released in 1998 for Kerala	Good culinary quality with short duration. Suitable for low land cultivation as a rotation crop in a paddy based cropping system.	25-28

The cassava varieties performing better and found suited to different states are given below (state-wise)

Andhra Pradesh	Sree Sahya, Sree Visakham, Sree Prakash, Sree Jaya, H-165, H-226
Assam	Co-1, Sree Sahya, H-165, Sree Visakham
Kerala	M4, H-97, H-165, H-226, Sree Visakham, Sree Sahya, Sree Prakash, Sree Jaya, Sree Vijaya
Karnataka	H-97, H-165, H-226, Sree Sahya, Sree Visakham
Maharashtra	SreeVisakham, Sree Sahya
Tamil Nadu	CO-1, CO-2, H-97, H-165, H-226, Sree Visakham, Sree Sahya, H-119, Sree Prakash, Sree Jaya
West Bengal	Sree Sahya, H-119
North-Eastern Region	Sree Sahya, Sree Visakham

5.5.2 *Agro techniques for different regions*

1. Time of Planting: Cassava is a rainfed crop and hence its successful planting and establishment depends much on rainfall. Time of planting for different states is given below.

State/Region	Time of planting	
	Rainfed	Irrigated
Kerala	April - May Sept - Oct	Dec – Jan
Andhra Pradesh, North-Eastern region, Chattisgarh	June	March
Tamil Nadu	May - June	Dec – Jan

2.Manures and fertilizers: For rainfed cassava crop in Andhra Pradesh, 60 kg/ha each of N, P_2O_5 and K_2O is recommended.

At Jagadalpur in Chattisgarh, a fertilizer dose of 75:50:75 kg NPK/ha and a spacing of 90 x 75 cm gave better yield. For short duration varieties like Sree Prakash and H-119, application of NPK @ 75:50:75 kg NPK/ha is recommended under a close spacing of 75 x 75 cm for Tamil Nadu. In Kerala, NPK @ 100:50:100 kg per ha for high yielding varieties whereas the same is 75:50:75 for local varieties.

Being a long duration crop, it is preferable to apply full dose of phosphorus, half dose each of nitrogen and potassium as basal and the remaining half dose of nitrogen and potassium after 45-60 days of planting along with the first inter-culture and earthing up operations. However, P application can be skipped for four years when the soil has high quantity of available P status. Thereafter, a maintenance dose of 25 kg/ha P alone need be applied.

Green manuring *in situ* with fast growing cowpea varieties (B-61 or C-152) can substitute FYM application to cassava in acid laterite soils of Kerala. Phosphorus application to this cropping sequence can be reduced to 50 kg as indigenous rock phosphate. So also the N dosage to cassava can be reduced to 50 kg/ha i.e. 50% of the present recommendation. Lime application @ 2000 kg CaO/ha at the time of land preparation is beneficial and helps to increase the yield besides the quality of tubers. Sulphur @ 50 kg/ha and application of micro-nutrients like zinc, boron and molybdenum @ 12.5, 10.0 and 1.0 kg/ha respectively as zinc sulphate, borax and ammonium molybdate were found to be beneficial.

3. Interculture: Interculturing in the early stages of the crop is essential for removal of weeds and thus improving the soil physical condition. The first interculturing and earthing up should be given 45-60 days after planting and the second, a month later. Care should be taken to avoid root damage during interculturing operations.

4.Irrigation: Irrigation is normally not practiced in Kerala where the crop is grown as rainfed, whereas, in certain parts of Tamil Nadu and Andhra Pradesh, supplementary irrigation is given for cassava. Supplementary irrigation during months of drought resulted in higher yield. Irrigation at approximately 25 per cent available moisture depletion level throughout the growing season could double the tuber yield. It also improves the quality of tuber through improvement in starch content and reduction in hydrocyanic acid (HCN) content.

5.Cropping system: Cassava is grown both as a sole crop and also under multiple cropping system. In Kerala, it is grown mostly as rainfed in homesteads and in small holdings for self-consumption. In Kerala, the major coconut and cassava growing state of India, cassava is intercropped in 20% of coconut stands. In newly planted coconut gardens, cassava performs well up to 5 years with good yields. Cassava varieties like H-165, Sree Visakham (H-1687) and Sree Sahya (H-2304) grow satisfactorily in coconut gardens. Intercropping of cassava with bunchy variety of groundnut and vegetable cowpea, and sequential cropping of cassava and paddy are found to be profitable in generating more income and employment opportunities.

In Tamil Nadu, cassava is grown mostly in Salem, Dharmapuri, Erode, Namakkal, Cuddalore and Kanyakumari districts. In Pondicherry state also, cassava is grown extensively. In Salem and adjoining areas, the crop is cultivated under irrigation and tubers are mostly used as industrial raw material for starch and sago mills. Recently, cassava is gaining popularity in East Godavari district of Andhra Pradesh for its industrial uses. In North-Eastern region, the crop is grown mostly in mixed stands of shifting cultivation in the hill-slopes as a purely rainfed crop.

6.Intercropping: Cassava is a long duration crop that takes 9-10 months for maturity and harvest. When planted on a spacing of 90 x 90 cm, it takes about 3-3$^1/_2$ months to develop enough canopy, and the available sunlight, water and nutrients between rows can be profitably utilized for raising short duration intercrops. Legumes are the most suited intercrops in cassava plantation. Intercrops like ground-nut (bunchy type TMV-2 and TMV-7) and french bean (Cv "Contender") were found to be promising and economical. These crops give an additional net income of Rs. 3000-5000/ha within 3-3$^1/_2$ months. Intercropping of black gram with cassava (variety CO-1) has been recommended for Tamil Nadu. Bellary onion (*Allium cepa* L.) is also found to be a profitable inter-crop in Tamil Nadu. In Andhra Pradesh, green gram or black gram is recommended which can increase tuber yield of cassava by 14% and can give 40% more return compared to cassava alone. Soybean and french bean are suitable intercrops in Assam. Slight modifications in the agronomic practices such as spraying, seed rate, fertilizer requirement may become necessary when intercropped depending on the intercrop as given below:

7. Cultivation details of intercrops

	Name of cultivar/ intercrop	Duration (days)	Spacing (cm)	No. of (rows)	Seed rate (kg/ha)	N:P:K (kg/ha)	Yield (kg/ha)
1.	Groundnut TMV- 2 TMV-7 Pollachi - 2	100	30x20	2	40-45	10:20:20	1200
2	French bean Contender Top cross – 4	70	30x20	2	40	20:30:40	2000
3	Cowpea (grain) S-488	90	30 x 15	2	20	10:15:10	800
4	Cowpea (veg .) B-61	65	90x20	1	8	10:15:10	3000

(Information on Region specific technologies was provided by AICRPTC)

6. Technology Transfer programmes

Transfer of Technology (TOT) is a process by which viable technologies which are developed and perfected at research institutes are transmitted to the farming community and other users through strategic programmes and appropriate methods. The CTCRI has taken the leadership in formulating and implementing TOT strategies for cassava in India and thus transfers technology directly to the user system through On-farm research mainly on cassava varieties, outreach field oriented programmes and by various extension methods viz. training, exhibition, demonstration etc., and indirectly through close liaison with Departments of Agriculture/Horticulture of various States as well as the NGOs. The channels of linkage with the departments and NGOs are through training programmes organised for extension personnel, Seminars, Workshops and Seed multiplication programme. The Departments in turn transfer the technologies through training programmes for the farmers, demonstrations mass media etc. to the user system.

6.1. National Demonstration

National Demonstration (ND) on cassava was the pioneering attempt to transfer cassava technologies on a specific programme basis during early seventies (1970-74). The main concept under ND is that unless Scientists demonstrate the technologies in the farmers field, their advice may not be accepted by the farmers and the demonstration plot should be sufficiently large so that the feasibility of raising a good crop can be strikingly and unquestionably demonstrated. Totally 27 NDs were conducted during 1976 on High Yielding Varieties of Cassava (HYVC) viz. H-97, H-165 and H-226 by the scientists with cooperation of the local extension agents and farmers in four States, Kerala (23), Tamil Nadu (2), Andhra Pradesh (1) and Karnataka (1). The demonstration have convinced the farmers that HYVC could give an yield to the tune of 40 t/ha. As a result of such proven potentialities, there was a great demand for seed materials especially from Tamil Nadu. A beginning on diffusion of HYVC was made due to ND.

6.2. Operational Research Project (ORP)

The programme was in operation during 1976-1980 in Vattiyoorkavu village in

Thiruvananthapuram district, Kerala, operated through an IDRC (Canada) funded scheme. The main theme of the programme is demonstrating the proven technology and concurrently studying the constraints on adoption. The major technologies promoted in ORP 1) Variety Sree Sahya (H-2304) and Sree Visakham (H-1687) and their scientific management 2) Cassava mosaic eradication. Totally 268 demonstrations were laid out in the selected village and undertook eradication of CMD in an area of 200 ha through method demonstration and campaign. The experience on the ORP has revealed that the root quality of the introduced cultivars is not comparable to that of land races, poor market demand for HYVC and farmers were reluctant to adopt in view of additional expenditure required for recommended practices.

6.3. Lab to land programme (LLP)

LLP is a massive TOT programme initiated by Indian Council of Agricultural Research (ICAR in 1979) targeting small and marginal farmers for Socio-economic upliftment. The programme emphasized direct participation of a multidisciplinary team of scientists and a multimix extension approach. The technologies transferred with respect to cassava are 1) HYVC H-226, Sree Sahya and Sree Visakham 2) Improved methods of cultivation 3) Inter-cropping cassava with groundnut and cowpea. The LLP has passed through eight phases since 1979 till 1996, during which sixteen villages from three states viz. Kerala, Tamil Nadu and Orissa were adopted benefiting directly more than 1700 families (Table 6.1).

Cassava demonstration plot under LLP

The impact study conducted on 1985 has clearly indicated that the technologies introduced could double the income from HYVC apart from income from the intercrop. The adoption behaviour of the beneficiary farmers had significantly improved due to the programme especially of HYVC and fertilizer adoption.

Table 6.1: *Sites of Lab-to-Land programme implementation and the yield of introduced HYV and recommended intercrops*

Phase	Village, State	No. of families	High Yielding Varieties	Average Yield HYV Cassava	Local cassava cultivar	HYV sweet potato	Groundnut intercrop	French bean/ Cowpea intercrop
I (1979-1982)	Karippur Kerala	50	Sree Visakham, Sree Sahya	28	15		0.60	-
	Manapuram, Kerala	60	Sree Visakham, Sree Sahya	29	15		0.44	-
	Munchirai, Tamil Nadu	60	Sree Visakham, Sree Sahya	24	14		0.6	-
	Gajjalnaickan Patti, Tamil nadu	30	Sree Visakham, Sree Sahya, H 226	30	19		0.83	-
II (1982-1984)	Anducode, Tamil nadu	45	Sree Visakham, Sree Sahya	35	14		0.29	-
	Pacode, Tamil nadu	30	Sree Visakham,	34	14		0.29	-
	Ayiroopara, Kerala	125	Sree Visakham,	36	15		0.25	-
III (1984-1986)	Sreekariyam, Kerala	100	Sree Visakham	26	15		0.5	0.47 (French Bean)
	Perinad, Kerala	75	H 226	38	18		-	-
	Phulbani, Orissa	25	Sree Visakham	-	-		-	-

Table 6.1. (Contd.)

Phase	Village, State	No. of families	High Yielding Varieties	Average Yield				
				HYV Cassava	Local cassava cultivar	HYV sweet potato	Groundnut intercrop	French bean/ Cowpea intercrop
IV (1986-1988)	Perumpazhuthur, Kerala	100	Sree Visakham	27	20		0.46	1.40
V (1988-1990)	Kulathoor, Kerala	100	Sree Visakham	29	18		0.59	1.3-
VI (1990-1991)	Poovachal, Kerala	100	Sree Visakham	23	14		0.3	-
VII (1991-1993)	Cherucode, Kerala	75	Sree Visakham	27	13	-	0.3	-
	Anacode, Kerala	75	Sree Visakham	27	16	-	0.35	-
VIII (1993-1995)	Anacode, Kerala	80	Sree Visakham	$25^{*}/34^{**}$				
IX (1995-1996)	Cherupani, Kerala							
	Kerala	60	Sree Visakham	31				
	Malayadi, Kerala							

* *Upland* ***Lowland*

Source: Anantharaman, M., Ramanathan, S., Edison, S. and Sivakumar, P.S. (2001) Transfer of Tropical Tuber Crops Technologies: Means Modes and Methods. CTCRI Technical Bulletin series No. 35, CTCRI, Thiruvananthapuram

The impact of the programme could be also felt in the spread of technologies to non- beneficiaries.

6.4 Institution Village Linkage Programme (IVLP)

Over the years TOT has focused on those technologies which have been standardized based on the criteria of increasing the productivity. Initially non adoption of technologies by resource poor farmers was attributed to inadequate support system like extension and then attributed to attitudinal constraints. This perception is largely the product of the basic assumption that technologies are good and are resource - cum - scale neutral. This does not receive factual support as is evident from failure of such technologies in a CDR system. This led to the thinking that technology must be evaluated in terms of both its technical performance under the environmental conditions prevailing on small farms and also in conformity to the goals and socio-economic organisation of small farm production systems. A more holistic approach through the process of diagnosis of problems, identification of technological interventions based on farmers' knowledge and from Institute research system and technology identification for various production systems of a social system complementing needs and resources and the relationship of various on farm and off farm by linking Institution and the village production system.

Cassava varieties evaluation under IVLP

The operation of IVLP has the following steps 1) Selection of operation area 2) Multidisciplinary team 3) Agro-eco-systems of selected village 4) Problem diagnosis 5) Alternative technologies identification for solving problem 6) Drawing action plan 7) Technology assessment 8) Extrapolation.

The IVLP included as many as six production systems. In cassava production system. three types of interventions were made namely (i) OFT on new HYVC

(ii) OFT on Nutrient management in cassava and (iii) Intercropping in cassava during the project period 1996-2005.

Under upland conditions of cassava cultivation, five varieties were evaluated viz. Sree Jaya, Sree Prabha, Sree Rekha and local varieties :1. Manja Noorumootan and 2.Narayana Kappa. Sree Rekha and Sree Prabha have recorded high tuber yield of 45 and 46 t/ha respectively. Farmers also assessed these varieties for possessing good cooking quality. Three cassava varieties were evaluated under low land conditions, a fast emerging potential production system for cassava. To the surprise, the local variety Ullichuvala has out yielded the other two released varieties Sree Vijaya and Vellayani Hraswa registering a yield of 42 t/ha which also enjoys a better niche in the local market currently. However it was observed that Vellayani Hraswa, a newly tested variety could also give a comparable yield 40 t/ha close to the Ullichuvala. In case of intercropping in cassava, cow pea variety. Arka Garima was most profitable intercrop with average pod yield of 2t/ha. . Bunchy varieties of ground nut like JL 24,TMV 2 etc were the next best intercrops with yield ranging from 700-900 kg/ha.

6.5. Testing and popularising of cassava varieties in Tamil Nadu

Tamil Nadu, known for its irrigated cassava production system, high productivity of cassava and sustaining the cassava based starch factories, is the largest producer of cassava in India. Hybrids from CTCRI viz., H-226 and H-165 are the ruling varieties since 1980s and hence it is long pending agenda of identifying new HYVC and their popularization. With this concept in mind, cassava varietal evaluation were undertaken in irrigated production system during 1998-2003. In the district- wise varieties evaluation, it was observed that varieties seldom exhibited consistency in yield, some of the varieties Sree Rekha and Sree Prabha had poor establishment and growth and Sree Jaya and Sree Vijaya were all

Testing and popularising of cassava in Tamil Nadu susceptible to CMD. The experience on the plight of varieties has revealed that instead of trying very few released varieties evaluated and released elsewhere, it is better to evaluate large number of varieties, both released and non-released for selection of appropriate varieties for this region which is considered to be the citadel of cassava.

6.6. Consultancy

CTCRI offers consultancy to large scale farmers and entrepreneurs, there by transferring the production and processing technologies. Project UPTECH is one where CTCRI gives consultancy on contract basis.

6.6.1. Project UPTECH

Project UPTECH set up by State Bank of India, in 1988, is an extension of management of consultancy services for supporting clients' efforts for modernisation. Its mission is to catalyse **Technology upgradation** in selected industry following the cluster of industries approach. UPTECH, for the first time has entered into improvement of agriculture and the processing of the produce from it, by selecting cassava crop and cassava based sago industries in Samalkot, East Godavari district of Andhra Pradesh. Through a memorandum of understanding, CTCRI offers technical support on production and processing by providing consultancy since 1998.

Sago Factories modernisation under Project UPTECH

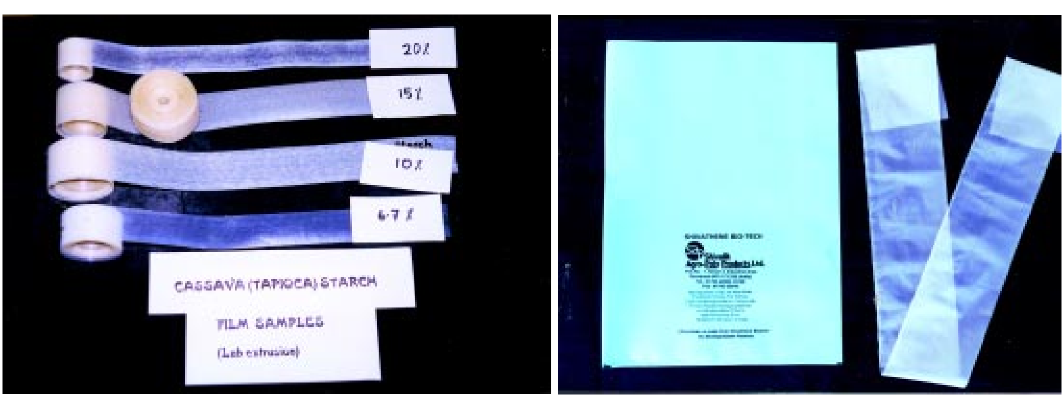
CTCRI transferred technology by providing consultancy on: Refinement of agro—techniques to improve yield and quality, Evaluation of high starch medium duration genotypes, Preservation of planting materials, Soil fertility management, Modernisation of sago industries to increase starch recovery, quality, reducing the cost of production, Participation in training, seminars, exhibitions and farmers day organised under the UPTECH. Nearly 120 scientist man days were spent by CTCRI in the project area.

6.7. Transfer of technologies on post harvest utilisation of cassava

1. Cassava chipping machines: Cassava chips are produced in various forms, sizes and shapes at different places. Sun drying of these chips (though traditional) is tedious and time consuming leading to uneven and delayed drying. To overcome these difficulties, CTCRI has developed hand operated, pedal operated as well as motorized cassava chipping machines. Hand operated chipping machine has been sold to 14 parties including the Govt. owned Kerala State Agro Industries Corporation. The CTCRI motorized chipper has been adapted by M/s Maruti Tapioca Products Ltd., Rajahmundry (Andhra Pradesh) in 1999.

2. Ethanol: The CTCRI technology for the process of manufacturing ethyl alcohol using cassava chips, flour or starch has been procured by M/s Superstar Distilleries, Kochi, Kerala and M/s Vairam Agro Fuels, Chennai, Tamil Nadu. The former had started commercial production and marketing.

3. Starch based biodegradable plastics: The CTCRI technology for manufacturing of starch based biodegradable plastics has been licensed (in 2000) to 4 parties M/s Shivalik Agro Poly Products Ltd., Chandigarh, M/s Trinayana Machines Pvt. Ltd., Haryana, Mr.Roopesh C.Shah, Bangalore and Mr Rajeshkumar & Mr Ravikumar Agarwal, Delhi in the states of Chandigarh, Haryana, Karnataka and Delhi. M/s Shivalik Agro Poly Products has already commenced commercial production. The unit at Bangalore, Karnataka is expected to commence production shortly using cassava starch.



Biodegradable plastics using cassava starch

4. Cold water miscible starch: The technology for production of cold water miscible starch was standardised and further modification based on the feed back from the industries. The basic lab scale work on the latter has been carried out in detail and is being tested for transfer to industries. One industry Vensa Biotek Ltd., Samalkot (A.P.) has purchased the technology for cold water miscible starch

6.8. Training programmes and other TOT activities

Apart from outreach programmes, cassava technologies are transferred through organising training programmes to extension personnel, farmers and students. The other TOT activities undertaken by CTCRI are participation in mass media both electronic and print, exhibition, popular articles, video production and presentation and distribution of planting materials.

Besides cassava technology programmes directly undertaken by CTCRI, the State Departments of Agriculture/Horticulture of Tamil Nadu, Karnataka, Andhra Pradesh and Kerala, are also involved in this process in a modest way. Basic information on improved cassava cultivation was provided to agricultural officers during training programmes who in turn pass on the technical knowledge to the cassava farmers. Kerala State Department of Agriculture had a special programme called ' Tapioca package programme' which was started in 1977 and ran up to 1981 during which 1959 single crop demonstrations and 1401 intercrop demonstrations were laid out in farmers field to popularize improved cultural practices and intercropping amongst the cultivators.

In Tamil Nadu, using training and visit programme (T&V) during the eighties, demonstrations were conducted in Salem district on high yielding varieties, basal and top dressing of fertilizers, intercropping, phosphate slurry treatment of setts, use of herbicides and control of lime induced iron chlorosis. The Department of Horticulture, Tamil Nadu implemented a special programme to popularize improved varieties in hilly regions of Salem district. In Kanyakumari district of Tamil Nadu too, adoptive research trials and demonstrations were conducted on variety Sree Visakam, use of chemical fertilizers and intercropping with ground nut.

7. Diffusion of technologies and their impact

Diffusion is the process by which an innovation is communicated through various channels over time among the members of the society. It is a kind of social change and often defined as the process by which attention occurs in the structure and function of a social system. Whenever ideas are invented, diffused and are adopted, they lead to certain changes occurring in agro-socio-economic conditions of farming community.

Impact implies the changes brought over by technologies or even in various dimensions viz., change in adoption of technologies, diffusion of technologies in specified geographical territory or economic improvement of the clientele intended. Impact measures can be interpreted as estimates of changes in economic improvement, behavioural practices of the users and diffusion of technologies transferred.

7.1 Varieties

Cassava is the major tropical tuber crop cultivated in India, occupying 63 per cent of the total area under root and tuber crops. Kerala, Tamil Nadu and Andhra Pradesh are the three states having the largest areas of cassava cultivation accounting for about 88 per cent of the country's total. A study conducted by Srinivas and Anantharaman (2005) on diffusion of cassava varieties in Kerala, Tamil Nadu and Andhra Pradesh revealed interesting information and the details are given for each state here below.

7.1.1 Diffusion of cassava varieties in Kerala

Diffusion of cassava varieties in Kerala is presented in Table 7.1. The study revealed that nearly 91 per cent of the cassava area was dominated by local varieties in Kerala, nearly 7 per cent was occupied by improved variety M4 and the remaining area was covered by high yielding varieties like Sree Vijaya (*Kariyela Poriyan*) and Sree Jaya (*Kottayam Chulli*)[1] . Anantharaman *et al* (1999) also reported that the enquiry

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[1] Kariyela Poriyan *is a local variety found in Thiruvananthapuram and Kollam districts, while Kottayam Chulli is a local variety found in Kottayam region of the state. These two local varieties were released as HYVs with names Sree Vijaya and Sree Jaya respectively by CTCRI. Thus in this study these varieties were considered as High Yielding Varieties (HYV).*

Table 7.1: *Diffusion of cassava varieties in Kerala by area*

Variety	Area (%)
Local	90.96
M4	7.32
Sree Vijaya (*Kariyela Poriyan*)	1.42
Sree Jaya (*Kottayam Chulli*)	0.29

Source: Srinivas T., and Anantharaman, M. 2006. Impact Assessment of Research Investment of cassava production technologies in India AP Cess Fund scheme of CTCRI.

Table 7. 2 : *Variety-wise percentage of cassava area in Kerala*

Name of the variety	Districts					
	Thiruvananthapuram	Kollam	Kottayam	Idukki	Malappuram	Palakkad
M4	20.66	2.85	—	9.16	—	13.86
Kariyela Poriyan/ Sree Vijaya	25.88	11.87	—	—	—	—
Kottayam Chulli/ Sree Jaya	—	—	1.36	—	—	—
Ullichuvala	19.36	—	—	—	—	—
Nadan Chuvappu	9.66	—	—	—	—	7.92
Kandhari Padappan	22.42	—	—	—	—	—
Mankuzhulandan	2.04	—	—	—	—	—
Vella Thandan	—	—	—	9.16	—	—
Mixture Vella	—	—	10.84	24.87	—	—
Ambakkadan	—	—	31.84	10.73	—	—
Mixture Chuvappu	—	—	55.96	9.55	—	—
Pathinettu	—	—	—	35.21	1.51	—
Kalikalan	—	—	—	1.31	—	—
Singapore Karupu	—	8.36	—	—	—	—
Aaru masa chuvappu	—	58.89	—	—	—	—
Aarumasa Vella	—	7.6	—	—	—	—
Ummen	—	4.27	—	—	—	—
Kottarakkara Vella	—	6.17	—	—	—	—
Diwan	—	—	—	—	69.13	73.66
Mixture	—	—	—	—		4.55
Malabar	—	—	—	—	29.37	—

Source: Srinivas T., and Anantharaman, M. 2006. Impact Assessment of Research Investment of cassava production technologies in India AP Cess Fund scheme of CTCRI.

made on Sree Vijaya and Kariyela Poriyan with farmers as well as scientists confirmed that both the varieties appear to be same. There were about 18 local cassava varieties cultivated in different regions of the state. M4 is largely under cultivation in Thiruvananthapuram, Palakkad, Idukki and Kollam. District wise distribution of varieties in Kerala is shown in Table 7.2.

In Thiruvananthapuram district maximum area was under *Kariyela Poriyan* (25.88 per cent) followed by *Kandaripadappan* (22.42 per cent), M4 (20.66 per cent) and *Ullichuvala* (19.36 per cent). Remaining 12 per cent was occupied by *Nadan Chuvappu* and *Mankozhundan*.

Aarumasa Chuvappu (58.89 per cent) was the leading variety in Kollam district followed by Sree Vijaya/*Kariyela Poriyan* (11.87 per cent). Improved variety M4 had only 2.85 per cent area in the district. The remaining area was covered by local varieties like *Singapore Karuppu*, *Aarumasa Vella*, *Kottarakara Vella and Ummen.*

Cassava area in Kottayam district was dominated by *Mixture Chuvappu* (55.96 per cent) followed by *Aambakkadan* (31.84 per cent) and *Vella Thandan* (10.84 per cent). Sree Jaya (*Kottayam Chulli)* was found having an area of 1.36 per cent of cassava area in the district.

In Idukki district local varieties *Pathinettu* was leading the area coverage with 35.21 per cent followed by *Mixture Vella* (24.87 per cent), *Aambakkadan* (10.73 per cent). Remaining area was occupied by local varieties like *Mixture Chuvappu, Vella Thandan and Kalikalan.*

In Malappuram district local varieties *Diwan* (69.13 per cent) and *Malabar* (29.37 per cent) were the dominant varieties followed by P*athinettu.*

Diwan (73.66 per cent) was the leading variety in Palakkad followed by M4 (13.86 per cent), *Nadan Chuvappu* (7.92 per cent) and *Malabar* (4.55 per cent).

Popular cassava variety M4

Ramanathan *et al* (1989) observed that local varieties occupied an area of 68.78 per cent of cassava in the state while M4 was in 25 per cent of cassava area and the remaining area was occupied by HYVs. The present study by Srinivas and Anantharaman (2005) is also confirming the fact that local varieties are dominating the cassava area in the state. H 165, H 226, Sree Visakham and Sree Sahya which were in 6 per cent of cassava area in the state during early eighties, were not at all found under cultivation now.

Diffusion of HYVs developed by CTCRI were found to be very meager among the farmers in Kerala. Since the crop is being cultivated for centuries, large number of local varieties are available in the State. As the bulk of the production goes for human consumption in the state, the local varieties some of which have excellent cooking quality and taste are preferred. The improved variety M4 introduced in the state during the 1960s is highly preferred for its excellent cooking quality and taste though its productivity is low. Varieties developed so far couldn't beat some of the local varieties and M4 for its excellent cooking quality and taste.

The cultivation of HYVs was confined to southern districts of Kerala viz., Thiruvananthapuram, Kollam and Kottayam. Nevertheless the chance of coming across hybrid varieties in the areas not covered under the present survey cannot be ruled out. Absence of HYVs in central and north Kerala is indicative of the inadequate extension efforts made so far in popularizing the HYVs among the farmers. Ramanathan *et al* (1989) also identified that lack of special programmes for cassava was one of the important constraints in the adoption of high yielding cassava varieties.

7.1.2 Diffusion of cassava varieties in Tamil Nadu

Percentage share of HYVs, improved variety and local varieties in Tamil Nadu is given in Table 7.3. There was not much variation in the high yielding and improved varietal spread of cassava in Tamil Nadu when compared to the study by Ramanathan *et al.* (1990). Similar trend has been continuing in the spread of cassava varieties since 1985. HYVs like H 226, H 165, Mulluvadi[2] etc. cover 80.42 per cent of total area in Tamil Nadu. Remaining area was covered by local varieties (19.29 per cent) like *KunkumaRose, Burma* etc. and improved variety M4

[2] ***An HYV released by Department of Agriculture, Tamil Nadu.***

(0.30 per cent). Among the HYVs H 226 was the leading variety covering almost half of the cassava area in the state. The variety was highly popular for good qualities suiting the industrial requirements like high starch content, low fiber content, its ability to withstand drought etc. and found mostly in rainfed production system (Table 7.4).

District wise diffusion of HYV, improved and local varieties are presented in Table 7.5. In Salem district nearly 85 per cent of area was covered by HYV H 226 followed by local variety *KunkumaRose* (9.32 per cent). HYVs like H 165, Sree Prakash, Sree Jaya, Sree Vijaya, Mulluvadi, CO 2[3], improved variety M4 had only meager coverage in the district. It may be noted that the variety H 165 is the dominating variety in all the hill and mountain production system of Tamil Nadu viz., Kolli hills (Namakkal), Kadambur hills (Erode) and Siddheri hills (Dharmapuri).

H 226 the most popular cassava variety in rainfed tracts of Tamil Nadu

Mulluvadi (71.98 per cent) was the dominant variety in Erode district. H 226 and *KunkumaRose* had coverage of 18.68 and 9.34 percentage of cassava area respectively. Namakkal District was dominated by H 226 (41.22 per cent) followed by *KunkumaRose* (28 per cent), H 165 (21.12 per cent), Mulluvadi (8.14 per cent) and Sree Prakash (1.53 per cent).

H 165 another popular cassava variety in Tamil Nadu

In Dharmapuri district 67.28 per cent area was covered by H 226 followed by Mulluvadi (27.78 per cent) and remaining 4.94 per cent by *KunkumaRose*. Villupuram

[3] ***An HYV released by TNAU, Coimbatore.***

***Table 7.3 :** Diffusion of cassava varieties in Tamil Nadu*

Variety	Area (%)
High Yielding Varieties	80.42
Local	19.29
M4	0.30

Source: Srinivas T., and Anantharaman, M. 2006. Impact Assessment of Research Investment of cassava production technologies in India AP Cess Fund scheme of CTCRI.

***Table 7.4 :** Different cassava varieties under cultivation in Tamil Nadu*

Variety	Area (%)
H 226	47.83
H 165	5.05
Sree Prakash	0.61
Sree Jaya	0.20
Sree Vijaya	1.83
Sree Visakham	0.51
M 4	0.30
Mulluvadi (MVD-1)	24.30
CO 2	0.08
Local	19.29

Source: Srinivas T., and Anantharaman, M. 2006. Impact Assessment of Research Investment of cassava production technologies in India AP Cess Fund scheme of CTCRI.

had maximum area under local variety *KunkumaRose* (32.01 per cent) followed by HYV Mulluvadi (27.81 per cent), H 226 (22.86 per cent), local variety Burma (13.40 per cent) and H 165 (3.90 per cent).

Kanyakumari was dominated by *Kariyela Poriyan* (40.50 per cent) followed by Sree Visakham (12.76 per cent) which was introduced in the district by CTCRI during the Lab-to-Land programme of the 1980s. Improved variety M4 had coverage of 4.85 per cent in the district. Many local varieties found in Kanyakumari were unique to the district as it was not observed in other parts of the State. It includes varieties like *Narukku* (12.24 per cent), *Karuthakani* (8.93 per cent), *Sundari Vella*

Table 7.5: Variety-wise percentage of cassava area in Tamil Nadu

Name of the variety	Districts					
	Salem	Erode	Namakkal	Dharmapuri	Villupuram	Kanyakumari
H 226	84.89	18.68	41.22	67.28	22.86	—
H 165	0.81	—	21.12	—	3.92	—
Sree Prakash	1.22	—	1.53	—	—	—
Sree Jaya	0.81	—	—	—	—	—
Sree Vijaya/ Kariyela Poriyan	0.81	—	—	—	—	40.56
Sree Visakham	—	—	—	—	—	12.76
Mulluvadi	1.42	71.98	8.14	27.78	27.81	—
CO 2	0.32	—	—	—	—	—
M4	0.41	—	—	—	—	4.85
Burma	—	—	—	—	13.4	—
KumkumRose	9.32	9.34	27.99	4.94	32.01	—
Ullichevala	—	—	—	—	—	4.85
Karuthakani	—	—	—	—	—	8.93
Sundari Vella	—	—	—	—	—	6.38
Narukku	—	—	—	—	—	12.24
Lakshmi Vella	—	—	—	—	—	4.34
Adukumuttan	—	—	—	—	—	2.55
Nadan Vella	—	—	—	—	—	1.02
Nadan Chuvappu	—	—	—	—	—	1.53

Source: Srinivas T., and Anantharaman, M. 2006. Impact Assessment of Research Investment of cassava production technologies in India AP Cess Fund scheme of CTCRI.

(6.38 per cent), *Ullichuvala* (4.85 per cent) *Lakshmi Vella* (4.34 per cent), *Adukkumuttan* (2.55 per cent), *Nadan Chuvappu* (1.53 per cent) and *Nadan Vella* (1.02 per cent).

7.1.3 Diffusion of cassava varieties in Andhra Pradesh

Among the three states considered in the study, Andhra Pradesh was the only state where HYVs were found to be occupying the entire area under cassava. More than half of the cassava area in the state (58.13 per cent) is covered by the H 165. It was followed by H 226 (29.78 per cent), Sree Jaya (11.66 per cent) and

Sree Prakash (0.43 per cent). Distribution of cassava varieties in Andhra Pradesh is shown in Table 7.6. On enquiry, it was noted that H 226 and H 165 had come from Tamil Nadu nearly three decades back Varieties Sree Jaya and Sree Prakash made their entry in the state through the collaborative project-Project Uptech, operated by State Bank of India (SBI) and CTCRI at Samalkot.

H 165 the dominant variety cultivated in Andhra Pradesh

Table7.6 : *Variety-wise percentage of cassava area in Andhra Pradesh*

Variety	Per cent
H 165	58.13
H 226	29.78
Sree Prakash	0.43
Sree Jaya	11.66

Source: Srinivas T., and Anantharaman, M. 2006. Impact Assessment of Research Investment of cassava production technologies in India AP Cess Fund scheme of CTCRI.

7.1.4 Diffusion of cassava varieties in Tribal areas

Kolli hills, presently located in Namakkal district of Tamil Nadu is of historical importance and enriched with medicinal plants inhabiting a major proportion of tribal farmers of Tamil Nadu. Cassava is presently the dominant crop in Kolli hills, occupying more than 50% of the cultivated area. It took its root during late seventies. The cassava in Kolli hills is a commercial crop for the tribals and changed the lifestyle of tribals in all the dimension of education, housing, food habits, indebtedness, dressing pattern, market orientation and material possession of the tribal farmers. It is amazing to see that the entire cassava

The only and one cassava variety H 165 being cultivated by tribal farmers in Kolli hills of Tamil Nadu

cultivation is monopolized by a single variety H 165 released from CTCRI. The entire production goes for the cassava based starch and sago factories situated in Namakkal and Salem districts.

Kalvarayan hills is another tribal settlement in Salem district of Tamil Nadu where cassava is cultivated predominantly by the Malai gounders of the hills. H 226, another cassava variety released from CTCRI is the sole variety cultivated in these hills.

Pachamalai meaning green hills has already become hill of cassava and of late cassava is becoming a money spinner for the Malai Gounders of Pachamalai. Cassava has made its entry during late eighties, is now occupying more than 80% of cultivated area in Pachamalai. Kadambur hills located in

The success of H 165 continues in Pachamalai hills of Tamil Nadu also

H 165 in Kadambur hills of Tamil Nadu

Erode district is no different from the tuber crop scenario of Pachamalai. Cassava is dominating the agricultural production system in many tribal settlements in this hills. Over the years since early nineties it slowly replaced minor millets from the cropping pattern of the tribal farmers as cassava fetches the tribals a better socio-economic situation for the assured market for the cassava tubers to the starch factories of Tamil Nadu.

H 226 covers a significant area in Siddheri hills of Tamil Nadu

Siddheri hills, Dharmapuri district of Tamil Nadu depicts the same story where cassava is leading tuber crop and decides the economy of tribal farmers. Cassava as a crop came to the hills during mid seventies. However improved varieties of cassava arrived during mid nineties and H 226 is dominant in these hills besides H165 and Mulluvadi.

7.1.5 Varietal spread in other States

Karnataka has a congenial atmosphere for extensive cultivation of cassava. Though it is restricted to certain districts and mostly local varieties at present. Introduction of improved varieties and adoption of required cultural practices can substantially increase production, but processing industries are yet to come up in Karnataka.

As reported, the area under cassava in other parts of India ranges from 2000-4000 hectares and tuber production from 3,000-22,200 metric tonnes. The varietal coverage in those states is not exactly known except in Assam where H-165 and Sree Prakash are prevailing. In the north-eastern states, cassava is mostly used for human consumption where improved table varieties can have a better acceptance. The crop is gaining importance very recently in the states of Gujarat and Maharashtra.

Thus high yielding varieties, improved varieties and local varieties are grown in India to the extent of 71.81, 1.49 and 26.69 per cent respectively.

7.2. Adoption of Production technologies

Status of cassava production described elsewhere could throw light on impact due to diffusion of cassava production technologies. Adoption of any technology is influenced by multidimensional factors, especially socio-economic ones. No agricultural technology could be expected to be fully adopted in the entire cropped area whatsoever be the commercial status of the crop. A survey was conducted by Srinivas and Anantharaman (2005) on adoption of cassava production technologies and the results and given below.

7.2.1 Kerala

Adoption quotient (AQ) of cassava farmers in Thiruvananthapuram was estimated to be 61.73 which was the highest among the six districts followed by Kollam (60.40), Kottayam (59.04), Idukki (56.25), Malappuram (54.99) and Palakkad (45.63). (Table 7.7).

Table 7.7: *Adoption quotient of cassava farmers in selected Kerala districts*

District	Overall Adoption Quotient
Thiruvananthapuram	61.73
Kollam	60.40
Kottayam	59.04
Idukki	56.25
Malappuram	54.99
Palakkad	45.63
Kerala	**56.34**

Source: Srinivas T., and Anantharaman, M. 2006. Impact Assessment of Research Investment of cassava production technologies in India AP Cess Fund scheme of CTCRI.

This shows that adoption of improved cassava production technologies is higher in Thiruvananthapuram followed by Kollam, Kottayam, Idukki, Malappuram and Palakkad districts. The average AQ of Kerala was worked out to be 56.34 which indicated that adoption level of improved technologies in the state is good.

Among the cassava production technologies considered, all the respondents were correctly adopting technologies like land preparation, sett making, sett length, planting method and storage of planting materials in all the six selected districts.

Nearly 86 per cent of the cassava farmers were correctly adopting the recommended practice of retaining two shoots per plant. The practice was correctly adopted by only 57.50 and 60.00 per cent of the farmers in Thiruvananthapuram and Kollam districts respectively. In the remaining districts all the farmers were found to be correctly adopting the practice.

Adoption of the recommended spacing was found to be low among all the districts except the southern districts of Kollam (100 per cent) and Thiruvananthapuram (83 per cent). In all other districts most of the farmers were adopting more than the recommended spacing under the misconception that more spacing gives higher yield per plant.

Only ten per cent of the cassava growers in the state were following management practices for controlling cassava mosaic disease like planting disease free planting

Cassava cultivation by tribals of Idukki district of Kerala under varied production systems

materials, removing severely affected plants from the field, using some pesticides to control white flies etc.

Most of the farmers were not using organic manure as recommended in all the selected districts. Only 12.0 per cent of farmers were correctly applying the organic manures as recommended.

Imbalanced use of fertilizers was observed in all the selected districts in the state. Most of the farmers were not applying the recommended dosage of N, P, K nutrients. On an average only 9.00 per cent, 11.00 per cent and 8.00 per cent of the total farmers were following the correct dosage of N, P and K fertilizers respectively. This indicates that there is considerable scope to increase the productivity of cassava in the state if farmers adopt these recommendations correctly.

7.2.2 Tamil Nadu

Value of Adoption Quotient (AQ) of cassava farmers in the selected districts were presented in Table 7.8. Adoption quotient of Cassava farmers in Salem was estimated to be 69.50 which was the highest among the six districts followed by Kanyakumari (67.54), Namakkal (65.54), Erode (62.13), Villupuram (61.30) and Dharmapuri (55.79). The average AQ of the Tamil Nadu was worked out to be 63.63 which indicated that adoption level of improved technologies in the state is high in the state.

Table 7.8. *Adoption Quotient of cassava production technologies in Tamil Nadu*

District	Adoption Quotient (%)
Salem	69.50
Kanyakumari	67.54
Namakkal	65.54
Erode	62.13
Villupuram	61.30
Dharmapuri	55.79
Tamil Nadu	63.63

Source: Srinivas T., and Anantharaman, M. 2006. Impact Assessment of Research Investment of cassava production technologies in India AP Cess Fund scheme of CTCRI.

Among the cassava production technologies considered, all the respondents were correctly adopting technologies like land preparation, sett length and planting method in all the six selected districts.

Adoption level was high for technologies like storage of planting material (97 per cent), retaining two shoots per plant (83 per cent) and application of organic manures (74 per cent). Adoption level was fairly good for cultivation of high yielding varieties (66 per cent) and adoption of correct spacing (61 per cent).

The crop is mainly grown under irrigated condition in the state (nearly 60 per cent). Kanyakumari district has the lowest area under irrigated crop as it is mainly grown as rainfed crop in upland conditions. Most of the farmers in the state are retaining two shoots per plant except for farmers in Erode and Villupuram where only 50 per cent of the farmers were following the practice as they use cassava leaves as fodder for their cattle when other fodders are not available.

Imbalanced use of fertilizers was observed in all the selected districts in the state. Most of the farmers were found to be giving over dosage of chemical fertilizers resulting in deterioration soil health and incurring economic losses. Around 13 per cent of the farmers are found to be applying the recommended dose. Farmers need to be made aware of the ill effects of over dose of chemical fertilizers so that the economic loss suffered by them can be minimized and soil health could be improved.

It was found that in Tamil Nadu only nine per cent of respondents were following management practices for controlling cassava mosaic disease like using disease free planting materials, using some pesticides to control white flies etc. which was very low.

7.2.3 Andhra Pradesh

Value of Adoption Quotient (AQ) of cassava farmers in the selected districts were presented in Table 7.9. Adoption quotient of cassava farmers in Andhra Pradesh was estimated to be 51.20 per cent which indicated that adoption level of improved technologies in the state is high.

Among the cassava production technologies considered, all the respondents were correctly adopting technologies like cultivation of high yielding varieties, land

Table 7.9: *Adoption quotient of Cassava farmers in the selected district of Andhra Pradesh*

District	Adoption Quotient					Overall Adoption Quotient
	Marginal Farmers (‹1ha)	Small Farmers (1-2ha)	Semi-medium Farmers (2-4ha)	Medium Farmers (4-10ha)	Large Farmers (›10ha)	
East Godavari	55.77	53.06	48.72	50.77	0	51.20
Andhra Pradesh	**55.77**	**53.06**	**48.72**	**50.77**	**0**	**51.20**

Source: Srinivas T., and Anantharaman, M. 2006. Impact Assessment of Research Investment of cassava production technologies in India AP Cess Fund scheme of CTCRI preparation, sett making, sett length and planting method. Nearly 86 percent of the farmers were retaining two shoots per plant.

Adoption level was found to be very low for technologies like recommended spacing between plants (5.56 per cent), application of phosphate (5.56 per cent) and potassium (2.78 per cent) nutrients and storage of planting material (11.11 per cent). None of the farmers were found applying recommended dosage of organic manures and nitrogenous fertilizers and adopting CMD management practices.

Imbalanced use of fertilizers was observed among farmers in the state. Most of the farmers were found to be using over dosage of chemical fertilizers deteriorating soil health and incurring economic losses. Farmers need to be made aware of the ill effects of over dose of chemical fertilizers so that the economic loss suffered by them can be minimized and soil health can be improved.

7.3 Processing and utilization

7.3.1 On-site field evaluation

Transfer of any post-harvest technology that was generated and tested in the Institute and subsequently further modified and refined in the laboratory, had been attempted in the past through on-site field evaluation studies. In this regard, mention may be made of the equipments such as the cassava harvesting devices, the hand-operated chipping machine and the pedal-operated chipping machine which had been evaluated under farmers conditions in different villages of Kerala and Tamil Nadu.

7.3.2 AICRP on PHT

CTCRI, Thiruvananthapuram has been functioning as one of the co-ordinating centers of the All India Coordinated Research Project on Post-Harvest Technology since the eighties. Under this Scheme, potential technologies have been exchanged for evaluation and popularization with other coordinating centers of the AICRP on PHT. The hand-operated chipping machine developed by CTCRI, for example had been sent to CIAE, Bhopal in 1988 for evaluation with regard to crops such as potato, sweet potato, carrot, radish, cassava, etc. Similarly this Institute had evaluated a cassava peeling machine developed by TNAU (in 1995), Coimbatore.

7.3.3 Display & sales in trainings / exhibitions

The Institute participates in various agro-industrial exhibitions organized at national, regional and local levels. The processes and products developed under home and farm- front technologies as well as those under cottage, small scale and large scale industry level are put on display for creating awareness of the farmer-cum primary processors as well as entrepreneurs. Sales of products developed at home and farm-front and cottage industry level are also made available on sales for a first hand testing and popularization. The Institute also organises training programmes from time to time for demonstration and dissemination of these technologies.

CTCRI Exhibition stall

7.3.4 Patents

The Institute has applied for / obtained patents for the following technologies in order to transfer those technologies to the potential clients while protecting the intellectual property rights in accordance with the recent guidelines of the Council.

Indian Patents

1. Hand-Operated cassava chipping machine (1985)
2. Ethanol from cassava (1983)
3. A Multipurpose mobile starch separation plant (1996)
4. A Process for extracting starch from cassava tubers

5. Starch-based biodegradable plastics
6. A process and design to reduce pollution load in waste waters of cassava starch / sago factories
7. Process for production of cold water miscible cassava starch
8. Fermented flour (2002)

International Patents

1. Starch-based biodegradable plastics (European Patent) (2000)

7.3.5 Transfer of technology through NRDC

The Institute has transferred some of its industrial technologies through the National Research Development Corporation, New Delhi, a Government of India enterprise specializing in this field. Under this mode

(a) The hand-operated cassava chipping machine design has been transferred to 11 parties

(b) The cassava ethanol process has been transferred to 2 parties and

(c) The starch-based biodegradable plastics process has been transferred to 4 parties.

7.3.6 Institute consultancy and transfer of technology

The Institute has also directly transferred a number of post harvest technologies. The technology for pollution control in waste waters of cassava starch / sago factories is being transferred to 2 parties in Salem (Tamil Nadu). The technology of Motorised Chipper has been transferred to a party in Rajahmundry (Andhra Pradesh). Recently the technology of process for production of cold water soluble cassava starch has been transferred to a party from Samalkot (Andhra Pradesh).

7.3.7 Project Uptech

One of the major and noteworthy consultancy programmes of the Institute in recent times is on Modernisation of cassava sago industry in Andhra Pradesh.

It has been undertaken as a Project Uptech programme sponsored by the State Bank of India in order to transfer both production and processing technologies to improvise the status of sago manufacturing in the cluster of cassava sago factories in the Samalkot region.

Under this programme modern machinery such as prototype raspers, hydrocyclones, centrifuges, impact mills are being evaluated for adoption in cassava sago industry. Investigations and recommendations are being made to improve the product quality, to minimize product losses and to increase the process efficiency.

7.4. Constraints in the adoption of cassava technologies

Adoption barrier studies of Anantharaman *et al.* 1986, revealed that practices such as sett hill, sett length and planting method were uniformly. A study conducted by Ramanathan and Anantharaman (1987) has indicated that farmers had given first place to the infrastructural constraints comprising non-availability of hybrid planting materials, lack of adequate knowledge and skill on improved cultivation practices, lack of special development programme. However farmer beneficiaries of lab to land programme expressed economic and marketing constraints such as high cost of cultivation, lack of proper marketing system, inadequate industrial exploitation, less price for hybrid tubers well adopted by majority of the farmers.

A good number of reasons were forwarded for the non-adoption/partial adoption of practices like improved varieties, groundnut intercropping, recommended fertilizer, spacing, number of shoots to be retained, and mosaic control. It was observed that non-availability of planting material was stated as the prime cause for non-adoption. The validity of the reason was tested by observing the adoption behaviour of farmers after distribution of improved planting materials which clearly showed that there was enormous improvement in the absorption of improved cassava hybrids proving the problem expressed as genuine. Partial adoption of recommended fertilizer was due to lack of capital. "Reasons for non-adoption of spacing of 90 x 90 cm were less spacing more population resulting in more yield and less spacing reduces heat and conserve moisture.

Farmers who have adopted retention of one shoot instead of two have attributed the reasons 'for the less spacing given one shoot is sufficient' and 'to get good plating material.' Lack of knowledge, lack of planting materials and no visible yield loss were expressed reasons for non-adoption of management measures for cassava mosaic disease.

Overall analysing of reasons for non-adoption of some of the recommended practices indicated that lack of knowledge and unavailability of the planting materials were the common reasons uniformly expressed.

This study has pointed out that the practice-wise barriers often restrict the adoption of certain practices much more severely than others. The variation in the acceptance of different practices bring out the fact that the farmers do not accept a non-technology as a complete package, instead they develop their package by modifying the recommendations based on their resources base and farm condition.

8. Cassava marketing system

Though cassava production centres are concentrated in Southern India, the marketing centres are distributed throughout the country for different value added products produced from cassava (Table 8.1). Cassava is consumed either directly as cooked tubers or the products prepared from cassava.

8.1 Human consumption market

Cassava is consumed as baked tubers, as fried chips and as a culinary item in Kerala, Tamil Nadu and Andhra Pradesh. Forty per cent of tapioca produced in Kerala is consumed as vegetable in the form of boiled tubers, fried and parboiled chips. Ten per cent of tapioca is converted into chips for making flour and for using in snack food preparations.

Contract merchants or village agents collect the tubers from farmers and supply to wholesalers in wholesale markets like Nedumangadu in Thiruvananthapuram district of Kerala. Retailers purchase from wholesaler for further distribution to consumers. Some cottage industries make fried chips in Kerala. They supply to bakeries in the surrounding towns for retail sales.

Cassava as food

Cassava was an important part of the diet of people below poverty line in the yester years in Kerala. But with the improvement in the standard of living and availability of cereals, people are shifting from cassava to cereals. Cassava along with fish forms a very good combination of carbohydrate and protein. Now it is common to find this combination of cassava and fish in big hotels and restaurants.

Cassava as food gaining popularity

In Tamil Nadu, cassava is consumed as fried chips. Petty vendors purchase raw tubers from wholesale market and convert into fried chips for selling. Fried chips are produced mostly during harvesting season of the crop. It is commonly found in Salem, Erode and Namakkal districts. Cassava is also consumed as baked tuber during the harvesting season. It is seen during the harvesting season in cities like Chennai and Coimbatore in Tamil Nadu. Quantum of cassava production used for human consumption is 20 per cent only and the remaining production is used in starch, sago and chips production. However in Kanyakumari district, the consumption pattern reflects Kerala state.

In Andhra Pradesh, very small quantities of tubers are consumed in baked form. Edible tubers are cultivated in very small area. During harvesting season, these tubers are sold in shandies. Another from of consumption is by preparing papads at home level. During the harvesting season it is common to see that farmers consume baked tubers in the field itself. It is a common belief among the public that consumption of cassava tubers results in knee joint pains. Ninety nine per cent of the production goes for industrial utilization in Andhra Pradesh.

8.2 Animal feed market

Cassava as an ingredient of cattle feed is gaining popularity in the recent past. Raw tubers, flour made from cassava dried chips, thippi and skin are the most common forms of cassava used as cattle feed. Besides cattle feed preparations, cassava thippi flour is also used in the fish and poultry feed preparations. Fresh cassava tubers to the tune of 30 per cent of cassava production in Kerala are used to feed cattle.

Cassava silage a potential animal feed

During the crop production season, it is common to see the feeding of dried leaves to cattle. Some farmers soak the dried chips and then feed them to the cattle. Buffaloes fed with cassava leaves and chips, showed improvement in the milk yield.

Cassava waste is mainly used as a source of carbohydrate and as a buffer in cattle feed formulations. Sand and

Silica content to the tune of six per cent is the most limiting factor in the usage of cassava waste as cattle feed.

Cassava waste (thippi & peel) is used relatively in less quantity than de-oiled rice bran (DOB). Most of the cattle feed preparations contain 5-10 per cent of cassava waste compared to 35-40 per cent of DOB. As the latter is preferred to cassava waste as it contains 16 per cent protein in addition to good quantity of carbohydrate as well as its availability throughout the year. Cassava waste faces stiff competition from DOB, maize and jowar. Only when price of cereal grains such as maize and jowar is high, industrialists are showing interest in cassava waste.

Cassava thippi & peel flour find a good market in Maharashtra where small dairy farm units use this flour in cattle feed preparations. In Andhra Pradesh and Tamil Nadu, this flour is used in cattle feed.

Thippi from starch and sago industries and peel from farmers making chips and starch and sago industries is procured by flour millers for making flour. Fine, rough, coarse flour and *bharada* flour are the four different flours prepared from cassava thippi and peel. Flour millers supply the flour to the wholesalers in Maharashtra and in turn it is supplied to secondary wholesalers through commission agents. Small dairies/ farms directly purchase them from wholesalers. Bharada quality floor is especially used in making swine feed. Cassava thippi and peel flour units are concentrated in East Godavari district of Andhra Pradesh and Salem district in Tamil Nadu. It is common to observe the feeding of cattle with raw tubers in Kerala.

The knowledge of using cassava waste as an ingredient of cattle feed is known to a very few cattle feed industrialists due to lack of publicity. When this factor is taken care of, cassava waste can find a good market in cattle feed industries in future.

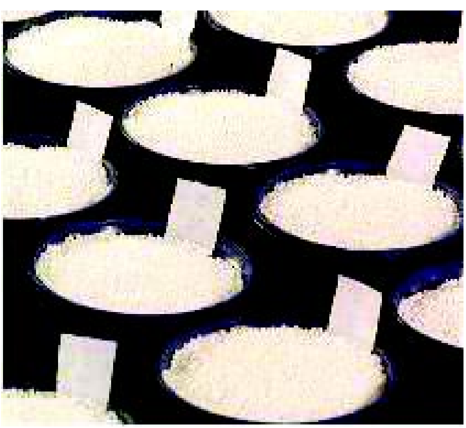
8.3 Market for commercial products

Many value added products of commercial importance are produced using cassava starch, sago, chips, flour etc.

8.3.1 Starch

It is the most important value added product produced from cassava. Approximately 400 starch processing units are located in Tamil Nadu. Starch is mainly used in the textile industry, in making adhesives, in pharmaceuticals, in paper industry, in confectionery industry etc. Eighty to ninety per cent of the cassava starch produced in India is from Tamil Nadu while the remaining quantity is from Andhra Pradesh.

In Tamil Nadu, fifty per cent of starch is marketed through SAGOSERVE and the remaining quantity is marketed directly or through commission agents by the millers to the wholesalers. Traders and primary wholesalers participate in the secret auction for purchasing the starch at SAGOSERVE. Primary wholesalers/traders are from Maharashtra, West Bengal and Gujarat. They further distribute the starch to secondary wholesalers either directly or through commission agents. Secondary wholesalers distribute to retailers in different places who in turn supply to the consumers. Commission agents charge one per cent of the value of the product as their commission. Wafer industries located in Namagiripet area of Namakkal district purchase wet starch for the preparation of wafers.




Marketing of sago and starch by SAGOSERVE - Participation of traders in secret auction

Only one industry M/s Vensa Bio-Tech, in Andhra Pradesh is producing cassava starch; further it produces liquid glucose from cassava starch. Five to six units in Kerala produce white and yellow dextrin using cassava starch.

In the recent past, India started exporting cassava starch from Chennai, Mumbai and Kolkata ports to Sri Lanka, USA, Australia, South Africa and the Gulf countries, though in small quantities.

8.3.2 Sago

Sago is another important value added product produced from cassava. Sago production units are located in Tamil Nadu, Andhra Pradesh, Gujarat and Maharashtra. Moti, Medium, Bada dana and Nylon Sago are the different types of sago produced in the country. Nylon sago is produced in Tamil Nadu and Andhra Pradesh while Moti dana is produced in Andhra Pradesh only. Nearly 400 sago producing units are located in Tamil Nadu while 26 units are located in Andhra Pradesh.

Though sago production is limited to Tamil Nadu and Andhra Pradesh, it is consumed throughout the country. Maximum sago is consumed in Maharashtra. *Payasam, Kichidi, Upuma, Bonda* are the different items prepared using sago. Sago is used mostly as baby food in West Bengal. In the remaining parts of the country, it is consumed mainly in preparing *payasam* and wafers.

Pune and Nagpur in Maharashtra and Kolkata in West Bengal, Patna in Bihar, Kanpur and Varanasi in Uttar Pradesh, Gauhati in Assam are the main marketing centres for sago in India besides the production centres in Tamil Nadu and Andhra Pradesh. Fifty per cent of sago in Tamil Nadu is marketed through SAGOSERVE which charges a sales tax of 2 per cent for the sago it transacts.

In Andhra Pradesh, it is marketed through commission agents and one to two per cent of the value of the sago transacted is taken as commission. It is also transacted on consignment basis. Sales tax @ 4 per cent is paid for the sago sold from Andhra Pradesh. While in West Bengal, there is no tax on sago as it is considered as baby food. Sago market in Andhra Pradesh is a buyers' market as traders are dominating the trade.

Demand for Sago is generally more during festival seasons and in *Sravan* month (August) due to more marriages being held then.

Since the traders dominate the sago trade in India, M/s SAGOSERVE helped in eliminating commission agents between processor and primary wholesaler but not between primary wholesaler and secondary wholesaler. Nowadays in the retail market, sago is marketed through an attractive consumer packets of ¼, ½, 1 and 2 kg sizes. It is also exported from Mumbai, Kolkata and Chennai ports under different names viz, *Sago Appalam, Sagopith* etc.

8.3.3 Chips

Cassava dried chips are produced in Andhra Pradesh, Kerala and Tamil Nadu. East Godavari district in Andhra Pradesh, Salem district in Tamil Nadu and Kozhikode, Kannur and Thiruvananthapuram districts in Kerala are the centres of chips production in India. Chips are prepared during the harvesting season by farmers and chip producing units. Village agents collect the chips from farmers and supply to flour millers. Flour millers collect chips from farmers directly also and the chips are used mainly to produce chip flour for further using it in textiles, making different food items, adhesive industry, corrugation industries etc.

Some stockists with the expectation of good prices during off-season collect chips from farmers and store in go downs and they apply banned chemicals like BHC for protecting from insects during storage.

Chips are also exported to European countries like Belgium and Italy, whenever there is export demand. Chips are exported mainly from Kakinada port. General problem expressed about the quality of chips from Andhra Pradesh is high percentage of sand and silica content.

In Andhra Pradesh and Tamil Nadu, the chips are mainly used in the preparation of food items called muruku besides their use in feeding cattle. Chip prices depend on factors like quality of chips, competition from millers, artificial scarcity created by stockist and the export demand.

8.3.4 Chip flour

Chip flour making units are concentrated in Andhra Pradesh, Tamil Nadu and Kerala. Chip flour is mainly used in textile industries, adhesive industry, Kumkum (Kumkum is the red colour powder used in poojas by Hindus and also as bindi by women folk) preparation, making colours, in corrugation industry and in preparing food items.

Ichhilkaranji in Maharashtra is a big centre for chip flour for using it as stiffening agent in textile industries. Industries manufacturing kumkum are located in Chennai. Colours are made using cassava chip flour in Hathrus district of Uttar

Pradesh, as adhesive in cracker industry at Sivakasi (Tamil Nadu) and for making food items called muruku in Tamil Nadu and Andhra Pradesh.

Chip flour is marketed either directly or through the commission agents to wholesalers. Commission agents charge one to two per cent of the value of the goods transacted as commission.

Barada quality flour is the flour prepared from small pieces of tubers. These tubers are peeled, chipped, dried and then ground to coarse powder. This powder is mixed with thippi and peel flour and is mostly used in animal feed industries and gum making.

8.3.5 Wafers

It is another important value added product from cassava starch; seventy wafer making cottage industries are functioning at Namagiripet taluk of Namakkal district in Tamil Nadu. These wafers are marketed through WAFERSERVE, (The Namagiripet Tapioca byproducts industrial cooperative service society Ltd.) It eliminated middlemen between processor and primary wholesaler to some extent.

Sago wafers in different shapes

Demand for wafers is more in northern states like Delhi, Gujarat and Uttar Pradesh besides Bangladesh and wafers are sold in attractive consumer packets. Involvement of brokers is limited in this trade.

8.4 Export trade

Cassava finds place in the international trade either in its raw form or in its processed form. India has been exporting cassava products since 1950's in different forms. Cassava exports declined after 1960's due to domestic food situation especially in Kerala. However in the late eighties, the exports picked up momentum.

Cassava is exported in different forms viz., Raw tubers, Frozen tapioca, Tapioca chips, Manioc starch, Tapioca & substitutes, Tapioca flour, Sago pith and Sago flour from different ports of the country (Table 8.2).

8.4.1 Raw tubers and frozen tapioca

Very small quantities of cassava raw tubers are being exported to Middle East and Gulf countries in two forms. 1.Raw tubers 2. Frozen tapioca

These exports are routed through Kochi sea port and from Kozhikode and Thiruvananthapuram air ports. Raw tubers are exported in cartons packed and filled with sawdust. The frozen tapioca is exported after peeling the tubers and cutting into small pieces and freezing at 18^{o} C in the frozen containers of ship. These exports are meant to meet the demand of ethnic Indian population in the Gulf and Middle East countries.

8.4.2 Tapioca chips

Dried cassava chips are exported mainly to European countries like Netherlands, Belgium, Italy and Russia. Even though published data shows that cassava chips were exported between 1972-73 and 1985-86, recent trade enquiries in Andhra Pradesh revealed that even in 1987-88,1992-93 1993-94 and 1995-96, dried chips continued to be exported from Kakinada port to the European countries. Some of the export specifications for chips are:

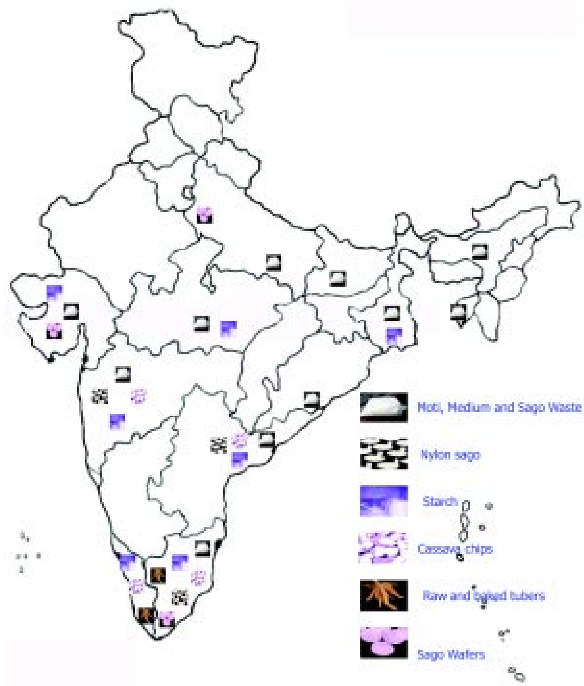
1. Moisture content of chips should not exceed 11%
2. Chips with fungus attack should not be more than 2%
3. Percentage of thin roots, chips with stem portion should not exceed 2%
4. Dust in the chips should not exceed 1.5 to 2%

Trade enquiries indicated that high percentage of sand and silica in the chips is the general problem in the quality of chips exported from India. If there is export

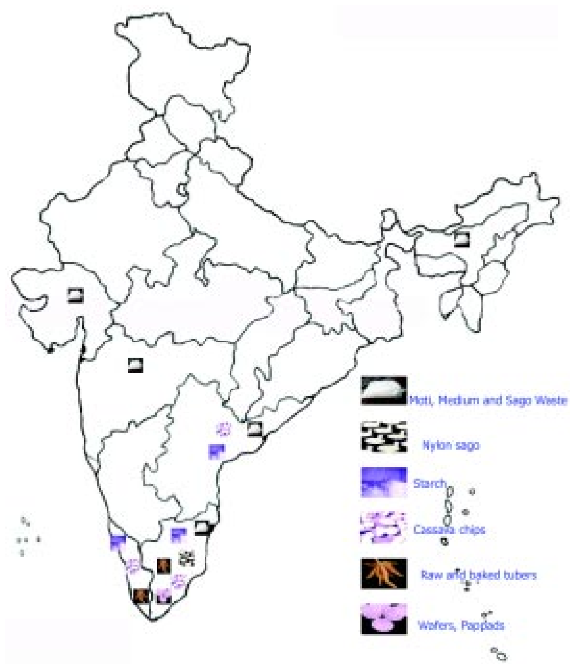
Table 8.1: *Production, marketing and consumption centres of Cassava and its value added products in India.*

Categories	Cassava product	Major production states	Consumer	Marketing centres
A	Sago: Moti dana & Medium dana	Andhra Pradesh & Tamil Nadu	Human consumption	West Bengal, Maharashtra Uttar Pradesh, Andhra Pradesh, Tamil Nadu, Assam, Tripura
	Nylon sago	Tamil Nadu & Andhra Pradesh		North India
	Sago waste	Andhra Pradesh & Tamil Nadu	For Sizing in Textile industry	Maharashtra, West Bengal
B	Starch	Tamil Nadu & Andhra Pradesh	Textile industry Adhesive manufacturers Liquid glucose, Dextrin manufacturers Confectionery Foundry Laundry Pharmaceuticals	Gujarat, Maharashtra, West Bengal
C	Chips & Flour	Andhra Pradesh & Kerala	Gum manufacturers Sizing clothes Animal feed industry Snack food manufacturers	Maharashtra, Andhra Pradesh
D	Wafers, Chips & Pappad	Tamil Nadu	Human Consumption	Gujarat, Delhi, Maharashtra, Tamil Nadu, Kerala
E	Raw tubers	Kerala	Human Consumption	Kerala, Tamil Nadu

Source: Srinivas T., and Anantharaman, M. 2005. Cassava Marketing System in India. CTCRI Technical Bulletin Series No. 43. CTCRI, Thiruvananthapuram.



Map showing major marketing centres of various cassava products in India



Map showing major production centres of various cassava products in India demand, then the chips collected by middlemen, commission agents and traders are exported. The importers will accept the produce only when the quality controllers (SJS and Geocum) certify that it meets the export specifications.

8.4.3 Manioc starch

Manioc starch exports started only recently from India i.e. from 1992-93 onwards. It is exported from Chennai, Mumbai and Kolkata ports to European countries and South East Asian countries. Our major problem in starch exports is the inconsistency in the quality of starch. During 1997-98 India exported 3,385.47 tonnes of starch earning Rs. 2.89 crores in foreign exchange. However, India is facing a stiff competition in (manioc) starch export from Thailand. India is not able to compete in the international market for cassava starch due to its poor quality and high price. Due to less production costs in Thailand, starch prices are less in Thailand in the global market compared to Indian prices.

8.4.4 Tapioca & substitutes

Under this group, various value added products prepared from cassava starch in the form of flakes, grains, pearls and siftings in smaller forms are exported. This group has a major share among the cassava exports from India. These products are routed through Chennai, Mumbai and Kolkata ports.

8.4.5 Sago pith and Sago flour

Published data shows that products under the headings sagopith and sago flour are exported from India. Therefore it is assumed that sago pith and sago flour are the products prepared using cassava starch. These exports are destined to Bangladesh and Middle East countries from Mumbai and Kolkata ports.

Cassava exports from India showed wide fluctuations over the years. Inconsistency in the quality of the product, competition from other countries like Thailand, inability to compete with international prices are found to be some of the reasons for the wide fluctuations in the quantity of cassava exports.

8.5 Channels of marketing

Marketing channels are the routes through which agricultural products move from producers to consumers. The length of the channel varies from commodity to commodity and depends on the market structure, nature of demand etc. Channels of marketing for cassava and its value added products viz., raw tubers, sago, starch, flour from chips, flour from thippi, and peel are identified separately. Well established market channels were observed for all the value added products. These channels are presented schematically in Figs. 8.1a to 8.1f and 8.2.

8.5.1 Raw tubers

Starch, Sago & Chip manufactures procure raw tubers from farmers either directly or thorough village agents. Snack foods like fried chips, baked tubers are produced using cassava. Quantum of snack foods produced is more in Kerala and Tamil Nadu. Manufacturers of snack foods procure raw tubers from farmers during production season; baked tubers are sold in weekly shandies. Fried chips are sold through retail outlets in Kerala.

8.5.2 Sago

Sago processor after procuring raw tubers from farmers either directly or through their agents process to produce Sago. Maximum quantity of sago produced in Tamil Nadu is routed through SAGOSERVE. Primary wholesalers who are members of the SAGOSERVE purchase sago by participating in the secret tender system and the remaining is sold either directly or through commission agents to primary wholesalers. Sago processors in Andhra Pradesh are wholly dependent on commission agents. Secondary wholesaler purchase from primary wholesaler either directly or through commission agent and distribute to consumer through retailer. Some sago processors and primary wholesalers are exporting sago as and when export demand is there. Sago market is concentrated mostly in Maharashtra & West Bengal.

8.5.3 Starch

In India ninety per cent of cassava starch is produced in Tamil Nadu and only a limited quantity is produced in Andhra Pradesh & Kerala. Most of the starch produced in Tamil Nadu is marketed through SAGOSERVE and only a limited quantity is sold either directly or through commission agents to primary wholesalers. Secondary wholesalers purchase from primary wholesalers and distribute to consumers through retailers. Involvement of commission agents between primary and secondary wholesaler is also observed. Some starch processors and primary wholesaler are exporting starch though in small quantities. Wafer industries purchase starch from starch processors.

8.5.4 Chips

Cassava chips are produced in Andhra Pradesh and to a little extent in Kerala and Tamil Nadu. Farmers and Chip processor producing chips supply them to flour miller through commission agents. Some stockists purchase chips in bulk during crop harvesting season, store in their godowns and sell them during non-season anticipating higher prices. Whenever there is an export demand, wholesalers collect chips from farmers, stockist and export them. In Kerala chips are sold in shandies and farmers purchase from them for feeding to cattle.

8.5.5 Wafers

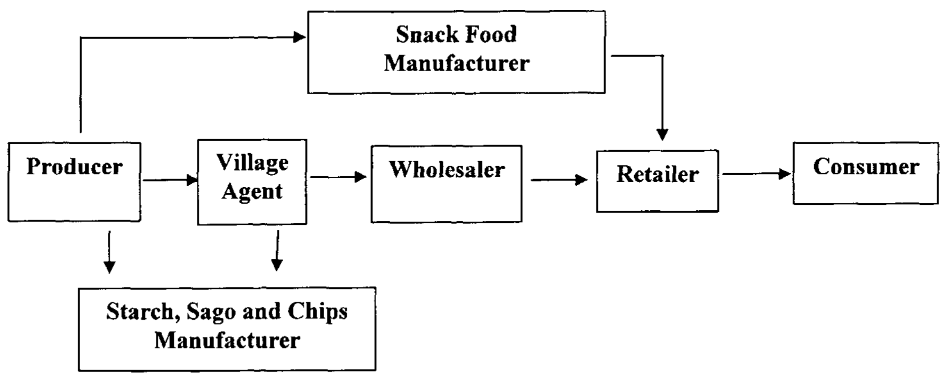
Wafer industries are concentrated at Namagiripet in Namakkal district of Tamil Nadu. Starch is being purchased from starch processors directly. These industries started WAFERSERVE (The Namagiripet Tapioca by products manufactures industrial cooperative Service Society) for marketing the wafers and to eliminate the role of middlemen. Only 5 to 10 per cent of sales are routed through commission agent. Wafers are mostly marketed to Ahmedabad, Indore, Kanpur, Jaipur and Delhi besides exports to Bangladesh.

8.5.6 Flour (chips, thippi and peel)

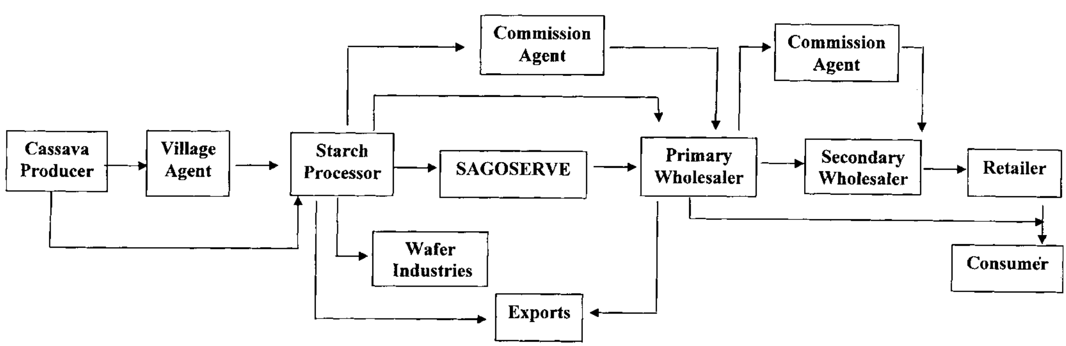
Flour is produced from chips, thippi and peel. Flour millers procure chips from farmers and chips stockiest and chips processor. Thippi & peel are the by products of sago & starch industries and are supplied to flour mills. Flour is marketed to wholesalers through commission agents.Flour is also purchased for use in animal feed mix plants.

Fig. 8.1. Market Channels for Cassava and its value added products in India

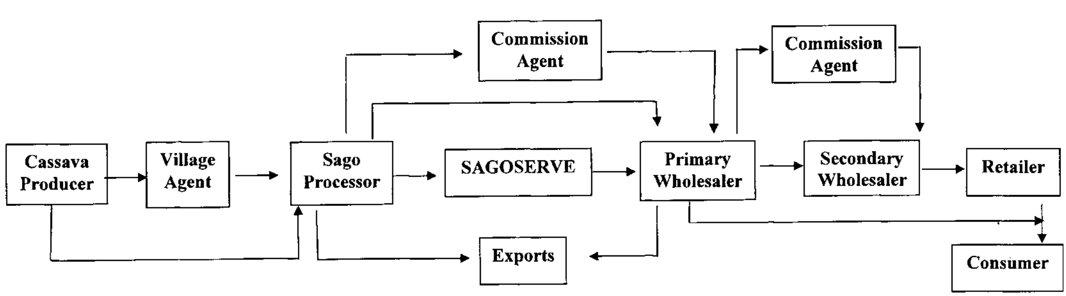
a. Raw Tubers



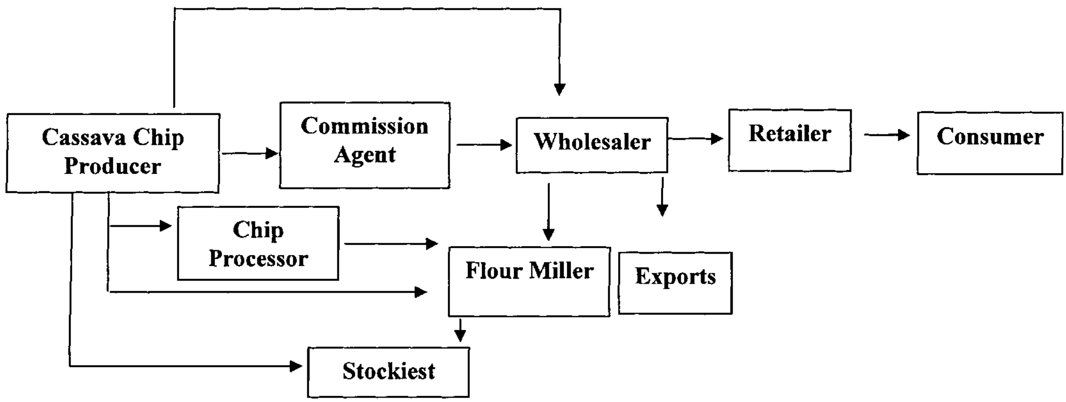
b. Starch



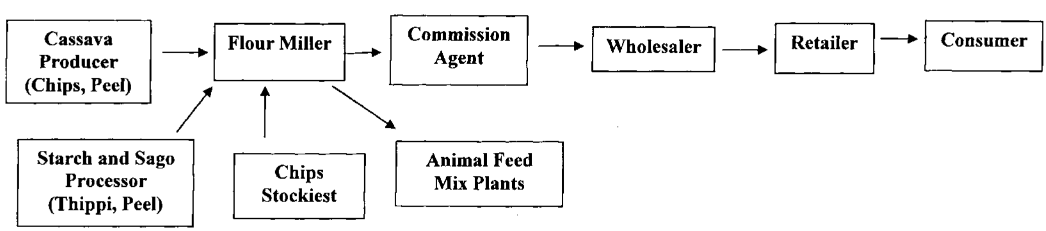
c. Sago



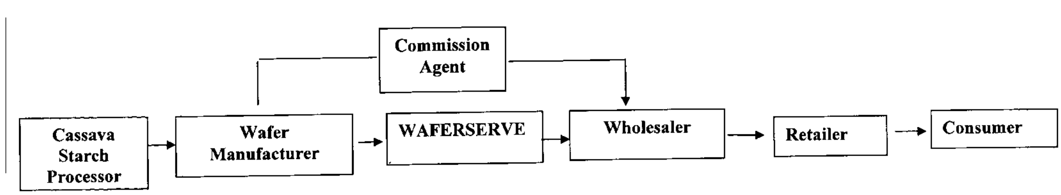
d. Chips



e. Flour (Chips, Tbippi and Peel)



f. Sago wafers



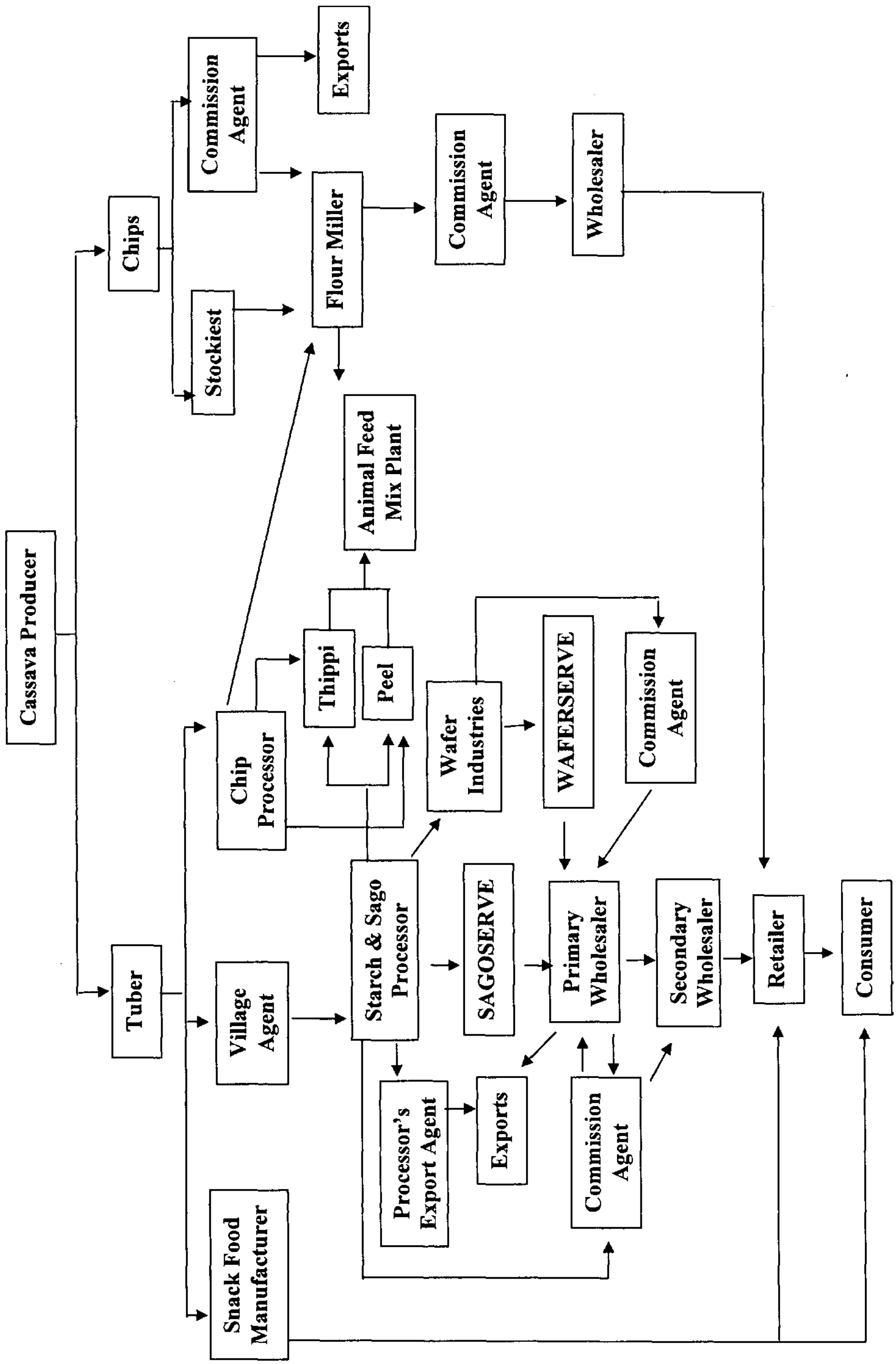


Fig. 8.2. Schematic representation of market channels for cassava and its value added products in India

9. Demand and supply projections

Information on current utilization pattern of any commodity, different sectors of its use, possible changes in the use with the changes in the policies of the Govt., availability of competing/substitution products is essential to predict or estimate the demand for the commodity in future. It is not only sufficient to estimate future demand, but also important to know whether this demand can be met in future with the available resources in the country. An attempt is made in this chapter to understand the demand and supply position of cassava by 2015-16.

9.1 Current utilization pattern of cassava

Cassava finds utilisation in three different sectors viz., Human consumption Animal feed and industries. Utilisation of cassava produced in the country in 1999-2000 is shown state wise and sector wise in Table 9.1.

a. Human consumption

It was estimated that 16.43% (8.70 lakh tonnes) of the cassava produced in the country during 1999-2000 was used for human consumption as fresh tubers after deducting 15% of the total tuber production as wastage during handling in different market chains from harvesting to till consumption. Nearly 5.44 lakh tonnes of fresh tubers were estimated to be consumed in Kerala, 2.91 lakh tonnes in Tamil Nadu especially in tribal areas, 0.35 lakh tonnes in Andhra Pradesh and other north eastern states of the country. Human consumption demand for cassava is subject to further decline at a rapid rate due to increase in per capita income growth, availability of cereals and other high calorie foods etc. Besides fresh tuber consumption, cassava is also consumed as parboiled chips and fried chips in Kerala and as fried chips in Tamil Nadu and Andhra Pradesh. Nearly 6.54 lakh tonnes of fresh tubers were estimated to be fed to cattle mostly in Kerala.

b. Industrial utilisation of cassava

1. Kerala

Based on the information collected from industries located in Kerala, Tamil Nadu, it was observed that even though there is no industrial utilisation of cassava

Table 9.1: *Utilisation of cassava in India in 1999-2000*

Sector	Cassava is utilised as	Kerala	Tamil Nadu	Andhra Pradesh	Other states	All India
	Actual produced (t)	25,63,500	34,25,500	1,66,100	80,600	62,35,700
	Wastage (15%)	3,84,525	5,13,825	24,915	12,090	9,35,355
	Actual available	21,78,975	29,11,675	1,41,185	68,510	53,00,345
Human consumption	As fresh tubers	5,44,744 (25%)	2,91,168 (10%)	706 (0.50%)	34,255 (25%)	8,70,873 (16.43%)
	As parboiled chips	1,08,949 (5%)	—-	—-	—-	1,08,949 (2.05%)
	As fried chips	2,17,898 (10%)	2,91,168 (10%)	—-	—-	5,09,066 (9.60%)
Industry	Sago	2,17,898 (10%)	9,75,000 (33.50%)	60,000 (42.50%)	34,255 (50%)	12,87,153 (24.28)
	Starch	2,17,898 (10%)	9,64,000 (33.11%)	25,000 (17.71%)	—-	12,06,898 (22.77)
	Dry chips	2,17,898 (10%)	3,90,340 (13.41%)	55,479 (39.30%)	—-	6,63,717 (12.50%)
Animal feed	As fresh tubers	6,53,693 (30%)	—-	—-	—-	6,53,693 (12.33%)

Source: Srinivas, T. and Anantharaman, M., 2005 Cassava marketing System in India. CTCRI Technical Bulletin Series No. 43, CTCRI, Thiruvananthapuram.

tubers in Kerala, tubers produced from the Kerala districts bordering Tamil Nadu are supplied to sago and starch industries located in Salem, Namakkal, Erode etc districts in Tamil Nadu. It was estimated that nearly 4.34 lakh tonnes of tubers constituting 20 % of the cassava production in Kerala in 1999-2000 were supplied to sago and starch industries in Tamil Nadu. It was also estimated that 0.22 lakh tonnes of tubers were converted into dry chips for supplying to flour millers in Tamil Nadu and Andhra Pradesh.

2. Tamil Nadu

Eighty per cent of the cassava production in Tamil Nadu was estimated to be used industrially for the production of sago, starch, dry chips etc. Sago industries consume major quantity of cassava production in Tamil Nadu i.e., 9.75 lakh tonnes of tubers constituting 33.5 per cent of the tuber production. Starch industries consume 9.64 lakh tonnes constituting 33.11 per cent of the tuber production in Tamil Nadu. 13.41 per cent of the cassava production in Tamil Nadu in 1999-2000 was estimated to be utilised in the production of dry chips.

3. Andhra Pradesh

In Andhra Pradesh, 99 per cent of the cassava production is being utilised in the production of sago, starch and dry chips. Sago industries consume 0.6 lakh tonnes of tubers while starch industries consume 0.25 lakh tonnes of tubers and 39.3 per cent of tubers are converted to dry chips.

A few sago industries are functioning in Maharashtra, Gujarat and Assam. Nearly 0.34 lakh tonnes of tubers are being utilised in the production of sago.

Thus in India nearly 60 per cent of cassava is used for industries in the production of sago, starch and dry chips. Twenty eight per cent of the total cassava production is estimated to be used for human consumption and 12 per cent of the tubers are used in animal feed sector.

9.2 Demand projections

a. Human consumption demand

National Sample survey Organisation (NSSO) under Central Statistical Organisation is the lead agency in the country for collecting primary data on consumption expenditure by rural and urban people in different income strata in different states and union territories in the country in different years and in various rounds. NSSO data on consumption expenditure in different rounds collected in 1973-74, 1977-78, 1983, 1993-94, 1994-95, 1995-96, 1996-97, 1998 and 1999-2000 was used for assessing the changes in the demand for cassava in human consumption sector in India over the years. Expenditure on cassava is collected under the item

Table 9.2: *Qty. (kg) of cereal substitutes consumed/person for a period of 30 days in different years reported by NSSO*

Year/ State	Kerala		Meghalaya		Mizoram		Arunachal Pradesh		All India	
	R	U	R	U	R	U	R	U	R	U
1973-74	6.99	3.64	—	—	—	—	—	—	0.56	0.18
1977-78	5.55	2.59	—	—	—	—	—	—	—	—
1993-94	1.62	0.68	0.42	0.06	0.11	0.02	—	—	0.06	0.04
1994-95	1.1	0.82	—	—	—	—	—	—	0.05	0.04
1995-96	1.05	0.43	—	—	—	—	—	—	0.04	0.03
1996-97	0.87	0.4	—	—	—	—	—	—	0.03	0.03
1998	1.09	0.54	—	—	—	—	—	—	0.05	0.03
1999-2000	0.96	0.45	0.4	0.12	0.05	—	0.22	0.14	0.05	0.03

Source: Srinivas, T. and Ramanathan, S. 2005. Current utilization pattern and demand for cassava in human consumption and animal feed sectors in India. Paper presented at National Seminar on Achievements and opportunities in post harvest management and value addition in Root and Tuber crops (NSRTC2) held at CTCRI, Thiruvananthapuram during 19-20 July 2005.

"Cereal Substitutes" in the survey schedule on consumption expenditure used by NSSO. Other food items included under cereal substitutes are Jack fruit seed, Mahua kernel, Mango kernel etc. As these items are consumed in relatively small quantities throughout the country, it is assumed that the quantity reported under cereal substitutes as equivalent to cassava consumption in the country.

Kerala, Meghalaya, Mizoram and Arunachal Pradesh are the states reporting relatively high cassava consumption.

Quantity (kg) of cereal substitutes consumed per person for a period of 30 days in different years reported by NSSO in different rounds were presented in Table 9.2. From Table 9.2, it is clear that over the years, the quantity of cereal substitutes consumption is declining at a rapid rate. During 1973-74, cereal substitutes consumption in Kerala in rural and urban areas was reported as 6.99 and 3.64 kg per person respectively where as by 1999-2000, the consumption of cereal substitutes has come down to 0.96 and 0.45 kg respectively in rural and urban areas.

After Kerala, consumption of cereal substitutes was reported to be more in Meghalaya (0.96 kg and 0.45 kg per 30 days in rural and urban areas respectively). For the country as a whole, the cereal substitutes consumption has come down from 0.56 kg and 0.18 kg in 1973-74 to 0.05 and 0.03 kg in 1999-2000 per person in rural and urban areas respectively. It implies the fact that consumption of cereal substitutes has been declining rapidly both in rural and urban areas possibly owing to the high per capita income, increased purchasing power and availability high calorie foods.

Expenditure elasticities for different expenditure groups on cereal substitutes in Kerala and in India in 1999-2000 were calculated and compared with the expenditure elasticities available for the period 1977-78 and 1983 (Table 9.3).

Table 9.3: *Expd. elasticities for different expenditure groups on cereal substitutes in Kerala*

Expd.	1977-78		1983		1999-2000	
Group	R	U	R	U	R	U
1	2.304	5.725	2.347	3.249	0.003	-0.025
2	1.058	2.787	1.601	2.156	-1.796	0.966
3	0.77	1.789	1.21	1.477	0.834	0.761
4	0.522	0.956	0.953	1.074	1.076	0.104
5	0.402	0.511	0.789	0.786	0.411	1.649
6	0.342	0.327	0.629	0.536	-0.36	0.739
7	0.279	0.119	0.498	0.31	0.257	0.499
8	0.22	-0.076	0.377	0.115	0.275	0.704
9	0.177	-0.219	0.269	-0.064	0.45	0.601
10	0.149	-0.318	0.175	-0.216	0.467	0.357
11	0.118	-0.423	0.092	-0.358	0.166	0.665
12	0.075	-0.568	0.036	-0.447	0.519	0.491
All	**0.145**	**-0.457**	**0.253**	**-0.086**	**0.357**	**0.356**

Source: Srinivas, T. and Ramanathan, S. 2005. Current utilization pattern and demand for cassava in human consumption and animal feed sectors in India. Paper presented at National Seminar on Achievements and opportunities in post harvest management and value addition in Root and Tuber crops (NSRTC2) held at CTCRI, Thiruvananthapuram during 19-20 July 2005.

Expenditure elasticities for both rural and urban areas in low expenditure groups were found to be more positive indicating the willingness to spend more on cereal substitutes in 1977-78 and 1983. But in the case of higher expenditure strata, the elasticities were declining at a rapid rate in rural areas and turned to be negative in urban areas indicating the fact that population with increased income/expenditure in rural and urban areas have the tendency to spend less on cereal substitutes.

But in 1999-2000, expenditure elasticities remained more or less same in both rural and urban areas both in Kerala and in India. There was not much influence of rural or urban difference in the consumption behaviour of cereal substitutes and most of the expenditure elasticities in different expenditure groups are less than 0.5 indicating very less elastic nature of consumers for cereal substitutes.

Based on the expenditure elasticities of consumption and population growth for the year 1999-2000 and growth in per capita income with 1999-2000 as base year, demand for fresh tubers for human consumption was worked out using the following formula.

$$D_{ct} = [d_{c0} + n_j \, (\Delta Y / Y_0)] \, P_t$$

Where D_{ct} = demand for cassava at time t

d_{c0} = Per capita consumption of cassava in the base period

n_j = income/expenditure elasticity of demand for cassava

ΔY =Change in per capita income between time t and 0.

Y_0 = Per capita income at the base period.

P_t = Population at time t

Projected human consumption demand for cassava in Kerala was presented in Table 9.4. It shows that the demand for cassava by 2005-06, 2010-11 and 2015-16 will be 2.93, 3.27 and 3.76 lakh tonnes respectively. Steep decline in human consumption demand for cassava may be due to increase in per capita income growth, availability of cereals and other high calorie foods etc.

Table 9.4: *Projected Demand for cassava in Kerala in human consumption sector. (1999-2000 as base period)*

Projected Year	Projected Demand (Lakh tonnes)
2005-06	2.93
2010-11	3.27
2015-16	3.76

Source: Srinivas, T. and Ramanathan, S. 2005. Current utilization pattern and demand for cassava in human consumption and animal feed sectors in India. Paper presented at National Seminar on Achievements and opportunities in post harvest management and value addition in Root and Tuber crops (NSRTC2) held at CTCRI, Thiruvananthapuram during 19-20 July 2005.

b. Industrial demand

Cassava starch finds applications in wide range of industries like textiles, corrugation box industries, paper conversion industry, liquid gums for domestic sector, paper industry etc. besides food industry i.e. sago production industries. Surveys were made to collect data on cassava starch demand in all these industries. Demand for cassava starch is being influenced by many factors such as Govt. policy on the industries where cassava starch finds application, availability of cheaper substitutes, fluctuating growth of the industries where cassava starch finds application, population growth, international trade in the context of WTO regime etc.

1. Textile industry

In the textile industry, starch is required for sizing of cotton yarn before weaving. Yarn of different counts (from 0's to above 80's) are produced from cotton fibre for the production of different cloth varieties i.e., coarse cloth in making dhotis, towels etc. to fine cloth to be used in making dress materials. Maize starch is the major competitor for cassava starch used for yarn sizing. Sizing industries located at Somanur area near Coimbatore and Ichhlakaranji (Maharashtra) indicated that cassava starch was preferred for sizing coarse yarn i.e., from 0 to 40's count while maize starch was preferred for sizing fine yarn i.e., 40's to above 80's counts. The average count of cotton spun yarn production in the country points towards high production of coarse yarn. The ratio of coarse yarn to fine yarn production during the last decade was 86:14 indicating production of more coarse yarn in the country. During the last two decades, the trend of production of cotton yarn has shown an increase by four per cent.

Currently the cotton textile industry is stagnant and is undergoing stiff competition with the synthetic substitutes. There is shift in the consumption expenditure from clothes to other consumer durables. The ratio of cotton and synthetic fabrics at present is 70: 30 compared to 90: 10 during 1980's indicating the shift in cotton cloth to synthetic fabrics usage over the period of past two decades. Leaving aside these negative factors, if one looks into the projected per capita cotton cloth availability and the positive growth trend in the production of cotton yarn during the last two decades, a favourable picture for cassava starch requirement in the textile sector can be observed. Sizing industries indicated that sizing materials constitute 10-12 per cent of the weight of yarn thus sized. Starch (cassava or maize),

Table 9.5: *Industry wise projections of starch requirement*

Industry	1999-2000 (t)	2005-06 (t)	2010-11 (t)	2015-16 (t)
Textile	50,000	60,877	69,208	78,253
Corrugation adhesives	46,000	1,19,000	1,92,000	3,09,000
Paper conversion	34,500	36,800	38,700	40,600
Liquid adhesives	200	220	240	260
Paper at 2 %	46,000	66,000	95,000	1,37,000
2.50 %	57,000	83,000	1,20,000	1,72,000
3 %	69,000	99,000	1,43,000	2,06,000
Others	25,000	30,000	35,000	40,000
Total demand 2 %	2,01,700	3,12,897	4,30,148	6,05,113
2.50 %	2,12,700	3,29,897	4,55,148	6,40,113
3 %	2,24,700	3,45,897	4,78,148	6,74,113

Source: Srinivas, T. and Anantharaman, M., 2005 Cassava Marketing System in India. CTCRI Technical Bulletin Series No. 43, CTCRI, Thiruvananthapuram binder, softener, water, wax, oil are the important raw materials used during sizing of yarn. Approximately there are 17 lakh looms in the country and nearly 3,500 sizing units are distributed throughout the country which meet the requirements of these looms. There is no record of number of sizing units existing in India.

It was estimated that the cotton yarn sizing industry is currently consuming nearly 50,000 tonnes of cassava starch. Projection of cassava starch demand in the sizing industry was based on population projections and projections of per capita availability of cotton cloth. The study indicated that by 2005-06, the sizing industry would require 60,877 tonnes of cassava starch, by 2010-11, the requirement would be 69,208 tonnes and by 2015-16, the sizing industry requires 78,253 tonnes of cassava starch.(Table 9.5)

2. *Adhesive sector*

By virtue of its good adhesive properties, cassava starch has become an important raw material in the adhesive sector. Cassava starch based adhesives finds important place of application in corrugation box industry, paper conversion industry and liquid gum industry. Maize starch is one of the competing raw materials in adhesive sector for cassava starch.

a. Corrugation box manufacturing industry

Kraft paper and starch (either cassava or maize) are the important raw materials in making corrugation boxes. These corrugation boxes are being used in all the industries like textiles, consumer durables, processed foods etc. These corrugation box manufacturers have an association "Federation of Corrugated Box Manufacturers of India" (FCBM) with nearly 1300 units as members, currently 8 lakh tonnes of kraft paper is being used every year in making 6,050 million sq. mt length of corrugation boxes. Currently most of the units are using cassava starch in making corrugation gums due to its good adhesive property and its low price over maize starch. Currently this industry is consuming 46,000 tonnes of cassava starch.

Cassava starch demand in corrugation box industry is a demand derived from total industrial growth in the country. The Indian economy has maintained robust growth for the past ten years. At the end of year 2005 A.D., the mood was very upbeat with industrial production growing at more than 10 per cent per annum and the corrugated industry is poised to grow at around 10-12 per cent. Considering these factors, cassava starch demand in the corrugation box industry sector shows a very favourable trend. Projected cassava starch demand in corrugation box industry by 2010, 2015 and 2020 were presented in Table 9.5. It is projected that nearly 1.19 lakh tonnes, 1.92 lakh tonnes and 3.09 lakh tonnes will be the cassava starch demand by 2010, 2015 and 2020 respectively.

b. Paper conversion industry

Paper cones and paper tubes are the important paper conversion products which finds a place in textile industry. Kraft paper, cassava starch or maize starch, yellow dextrins are the raw materials in making paper cones and paper tubes. Starch is used in making paper cones while yellow dextrins are used in making paper tubes. There are nearly 600 paper cone making units and 400 paper tube making units in India. South based units are consuming cassava starch and it is based on yellow dextrins while north based units are using maize starch and yellow dextrins made from maize starch. On an average, 10 per cent of the weight of cone or tube is the wt. of either glue or yellow dextrin. Currently the industry is consuming 34,500 tonnes of cassava starch.

Cassava starch in paper conversion

Demand for the paper conversion products is a derived demand from the textile industry requirement. Paper conversion industry is stagnant due to non-remunerative prices and stiff competition. At a nominal growth of one per cent, the projected demand of cassava starch by 2020 A.D. will be nearly 42,000 tonnes.

c. Liquid adhesives for office use

Industrial survey indicated that cassava starch is the mostly used raw material in making liquid gums for office use. Camlin Ltd. having monopoly with nearly

80% of market share in liquid gum making is using cassava starch for making these gums. Currently this industry is consuming 200 tonnes of cassava starch per annum.

Cassava starch liquid gum

3. Paper industry

Data were collected from the starch and paper industries and from Central Institute for Research on Cotton Technology (CIRCOT), Mumbai were compiled and estimated the demand for cassava starch in paper industry (Table 9.5). Cassava starch and maize starch are being used in paper industry mainly to produce coated papers. Cultural paper, industrial paper, security paper and newsprint are the four different groups of paper produced in India. Nearly 50 per cent of the paper requirement in India is of cultural paper requiring starch coating. Demand for paper depends on factors like GDP growth rate, increase in per capita income, literacy rate, growth of service sector, advancement of printing technology in the country and development of packaging industry and development of paperless transaction. At present starch is used @ 2 per cent, 2.5 per cent and 3 per cent in paper production. Assuming that per capita consumption of paper and paper board grows at 6 per cent per annum, starch requirement for different types of paper at different use levels were worked out. By 2005-06 A.D., 1.33, 1.67, 1.99 lakh tonnes of starch will be required at 2 per cent, 2.5 per cent and 3 per cent level of use of starch in paper production respectively; while by 2010-11, 1.91, 2.39, 2.86 lakh tonnes of starch will be required at 2 per cent, 2.5 per cent and 3 per cent level of use of starch in paper production and by 2015-16, 2.75, 3.44, 4.13 lakh tonnes of starch will be required at 2 per cent, 2.5 per cent and 3 per cent level of use of starch in paper production respectively. Assuming that 50 per cent of the starch used in the paper industry is from cassava, it can be projected that by 2005-06, 0.66, 0.83, 0.99 lakh tonnes will be the demand for cassava starch at 2 per cent, 2.5 per cent and 3 per cent level of starch use; by 2010-11, 0.95, 1.19, 1.43 lakh tonnes and by 2015-16, 1.37, 1.72 and

2.06 lakh tonnes will be the cassava starch requirement at 2.0 per cent, 2.5 per cent and 3 per cent level of starch use respectively.

c. Animal feed sector

Surveys were made in animal feed industries in Tamil Nadu and Andhra Pradesh and collected information on use of cassava in animal feed making. Information from Animal nutritionists in Tamil Nadu University of Veterinary and Animal Sciences (TANUVAS) regarding the use of cassava in animal and poultry feed industries were collected through opinion survey.

There is a large gap between demand and supply of animal feed in the country. The total feed production in the organized sector is around five million tonnes against the total demand of 42 million tonnes. More than eighty per cent of the compound animal feed produced by the members of the Compound Livestock Feed Manufacturers Association (CLFMA) is being consumed in Southern and Western regions of the country. Based on the livestock population growth, total demand for animal feed by 2010 A.D. is estimated to be 68 million tonnes. Studies conducted on use of cassava as animal/poultry feed revealed that up to 30 per cent of the total ingredients can be from cassava in making the feed as a source of carbohydrate. But in practice only 5-10 per cent of the raw material in compound feed is from cassava in the form of cassava thippi and that to only in south India where cassava starch and sago industries are concentrated. Assuming that cassava to the extent of 5 to 10 per cent will continue

Table 9.6: *Projected cassava demand in organized animal feed sector (million tonnes)*

Year	Projected compound feed production by CLFMA in		Compound feed with cassava waste at	
	All India	South India	5%	10%
2000-01	2.2	1.14	0.05	0.11
2005-06	3	1.52	0.07	0.15
2010-11	4	2.03	0.1	0.2
2015-16	5.4	2.7	0.13	0.27

Source: Srinivas, T. and Ramanathan, S. 2005. Current utilization pattern and demand for cassava in human consumption and animal feed sectors in India. Paper presented at National Seminar on Achievements and opportunities in post harvest management and value addition in Root and Tuber crops (NSRTC2) held at CTCRI, Thiruvananthapuram during 19-20 July 2005.

to be used in the compound feed industry in south India, it is estimated that 0.07, 0.10, 0.13 million tonnes will be the demand for cassava thippi by 2005-06, 2010-11 and 2015-16 respectively at 5 per cent use level of cassava thippi. While at 10 per cent use level of cassava thippi in the compound feed making, projected demand is estimated to be 0.15, 0.20,0.27 million tonnes by 2005-06, 2010-11 and 2015-16 respectively (Table 9.6).

9.3. Demand-Supply projections for cassava starch in India

Cassava starch requirement in different industries of its use in the current year 1999-2000 and the projected starch requirement for 2005-06, 2010-11 and 2015-16 were presented in Table 9.7.

Currently cassava starch is being used in large scale in adhesive industry in the form of corrugation, paper conversion and stationary adhesives then followed by paper and textile industry. The use of cassava starch as adhesive is likely to go up in future due to its suitability to make good adhesive. Cassava starch requirement projections are based on the possible growth of the respective industries and the use of cassava starch as raw material and also on the population growth rate in India.

It was projected that by 2015-16, cassava starch required in adhesive sector alone will be 3.5 lakh tonnes followed by paper industry (2.0 lakh tonnes), textile industry

Table 9.7: *Demand-Supply projections for cassava starch in India*

Projected period	Demand (t)	Supply (t)	Gap (t)
2005-06	3,12,897	2,65,387	47,510
	(15,64,485)	(13,26,936)	(2,37,549)
2010-11	4,30,148	3,09,791	1,20,357
	(21,50,740)	(15,48,957)	(6,01,783)
2015-16	6,05,113	3,54,196	2,50,917
	(30,25,565)	(17,70,978)	(12,54,587)

Note: Figures in the parentheses indicate cassava tubers equivalent of starch in the respective box

Source: Srinivas, T. and Anantharaman, M., 2005 Cassava marketing system in India. CTCRI Technical Bulletin Series No. 43, CTCRI, Thiruvananthapuram

(78, 000 tonnes) and other sectors like food, laundry, pharmaceuticals etc. shall be 40,000 tonnes. Thus there will be a total demand of 3.12, 4.30 and 6.05 lakh tonnes of cassava starch for various industrial applications by 2005-06, 2010-11 and 2015-16 respectively.

From the supply side, it was estimated that only 2.65 lakh tonnes, 3.09 lakh tonnes and 3.54 lakh tonnes of cassava starch can be produced in India by 2005-06, 2010-11 and 2015-16 respectively. These projections are based on the growth rate of starch sales in SAGOSERVE, growth rate of starch industry in Tamil Nadu, Andhra Pradesh in traditional states and in non-traditional areas like Maharashtra, Gujarat and North Eastern states.

It was estimated that there will be a gap of 0.47, 1.20 and 2.50 lakh tonnes between demand and supply of cassava starch in India by 2005-06, 2010-11 and 2015-16 respectively.

9.4. Demand-Supply projections for sago in India

Demand –Supply projections for sago in India for 2005-06, 2010-11 and 2015-16 were presented in Table 9.8. From the table 9.8, it can be observed that there will be a demand of 2.62, 2.85 and 3.05 lakh tonnes of sago by2005-06, 2010-11 and 2015-16 respectively. Demand projections were based on the population growth rate and per capita availability of sago in India.

Supply projections were based on the growth rate of sago sales in SAGOSERVE, growth of sago industry in Tamil Nadu and Andhra Pradesh in traditional states and in non-traditional areas like Maharashtra, Gujarat and North Eastern states. It was estimated that there is a possibility of supply of 2.09, 2.41 and 2.74 lakh tonnes of sago by 2005-06, 2010-11 and 2015-16 respectively.

Thus there will be a gap of 0.55, 0.44 and 0.32 lakh tonnes of sago between demand and supply by 2005-06, 2010-11 and 2015-16 respectively in India.

The projected demand-supply gap in the industrial sector alone is worked out to be 1.5 million tonnes of cassava tubers requiring another 0.75 lakh ha to be brought under cassava cultivation. New and potential areas in the non-traditional states are to be considered for area expansion under the crop.

Table 9.8: *Demand-Supply projections for sago in India*

Projected period	Demand (t)	Supply (t)	Gap (t)
2005-06	2,64,793	2,09,441	55,352
	(16,25,245)	(12,56,644)	(3,68,601)
2010-11	2,85,341	2,41,724	43,617
	(17,51,372)	(14,50,342)	(3,01,030)
2015-16	3,05,819	2,74,007	31,812
	(18,77,054)	(16,44,040)	(2,33,014)

Note: Figures in the parentheses indicate cassava tubers equivalent of sago in the respective box.

Source: Srinivas T. and Anantharaman, M. 2004. Industrial demand for cassava in India. In: Proceedings of national seminar on Sago "Sago India 2004", Salem p. 101-107

New sago industries started in Gujarat, Maharashtra, Assam etc will act as stimulator to the local farmers to bring more and more area under cassava cultivation.

In Kerala, area under the crop is declining year after year as the importance of cassava in the food basket of the people of Kerala has been declining. It is the need of the hour on the part of the state Govt. to encourage potential entrepreneurs and industrialists to start industries to produce diverse value added products from cassava. R & D institutions like CTCRI will always be there to help these entrepreneurs to give consultancy on technological issues.

In the era of declining subsidies, the Govt. is restricting the number of crops for which minimum support prices are announced. Even under these circumstances, considering the economic potential of the crop in the region, covering states like Tamil Nadu and Andhra Pradesh, it is necessary to announce minimum support price for cassava starch units based on specific gravity machine to protect the interests of the farmers in the long run. It will protect the poor cassava farmers from the existing uncertainty in the prices of tubers. Once the minimum returns are assured, farmers may even go for capital investment in the form of developing irrigation infrastructures etc.

10. SWOT analysis for cassava

Analysis of strengths, weaknesses, opportunities and threats of any commodity is a *sine qua non* to programming of any enterprise. It can act as an important tool for projection of the strong and weak points apart from understanding of related/ relevant threats and opportunities. The SWOT analysis done based on review and discussions with experts on cassava in India by Anantharaman and Ramanathan (1999) is narrated below

10.1 Strengths

Unique features

Cassava has the potentiality to produce high amount of carbohydrate per unit area. The calorific yield per unit area of this crop is comparatively high because cassava is capable of converting large amount of atmospheric CO_2 to carbohydrates efficiently utilizing solar energy. The productivity and dry matter production (biological efficiency) are higher than that of other food crops. Cassava can produce $250x10^3$ calories/ha/day compared to $176x10^3$ for rice and $110x10^3$ for wheat (Mandal, 1993) indicating its superiority over cereals in terms of energy yield and the carbohydrate production is also estimated at about 6.76 t/ha compared to 0.8 t/ ha in the case of rice or wheat (Mandal, 1993). Cassava is championed for its adaptability to wide variations of soil, climate and environments of tropics from dry to humid and sunny to partially shaded conditions. The classical example to this fact is the phenomenal growth of cassava in harsh semi arid environment in Tamil Nadu and Andhra Pradesh (Ghosh, 1996).

Cassava is relatively free from pests and diseases barring cassava mosaic disease (CMD). However, the severity of CMD is not being reflected on the yield as evident from the productivity figures in Salem district of Tamil Nadu with 32 t/ha which is probably the highest yield reported from on farm situations. Salem district is referred as the hot spot of CMD (Nair and Thankappan, 1991).

Research base

A strong research base of cassava exists in India with CTCRI providing the leadership and All India Coordinated Research Project on Tuber Crops under its fold to give networking research support from 10 centers of State Agricultural Universities created in various parts of the country for attending to location-specific problem-oriented research. A contingent of about 90 Scientists are involved on the basic and applied research on tuber crops including cassava. The budget allocation also showed a steady increase to the extent 20 times (Tuber Crops) since fourth five year Plan (1969-74) to the X five year plan (2002-07).

Technology base

As a corollary to the sound research infrastructure, a rich stock of genetic resources of cassava viz., more than 1500 and a host of production technologies are available for mono-crop, intercrop and multicropping system which help in enhancing yield potentiality and area expansion. The impact of R&D efforts could be well observed in the average yield of cassava in India at 27.92 t/ha which is more than double that of the world (10 t/ha) and is the highest among major cassava producing countries. Also it could be observed that the productivity of cassava has shown a tremendous increase with annual compound growth rate of 1.3% since 1975.

Social security

Cassava provides enormous food security to weaker section especially in Kerala. Nearly 2.8 M.T. of cassava is consumed annually in the state of Kerala, which is 23.2% share of cassava in total cereals. (Ramasundaram *et. al* 1996). Apart from the food security angle, cassava cultivation generates employment of 212 man days/ha in rainfed and 332 in irrigated areas of Tamil Nadu and 214 man days in low land and 136 man days in upland production system of Kerala and 189 man days and 172 man days in irrigated and rainfed production systems of Andhra Pradesh respectively (Srinivas et al, 2003). In the processing front nearly 10-12 man days are required to process one tonne of starch/sago (Sagoserve, 1990). It is estimated that nearly 5 lakh people are making their livelihood based on cassava fields and factories in Salem district.

10.2 Weaknesses

Government policy

Unlike other crop enterprises which have due recognition and share in the

Government policies, cassava has been continuously sidelined in the development policy both at the Government levels. Lack of will on the part of Government to extend its realistic and pragmatic support in favour of cassava has further orphaned the crop. This has been rightly pointed out by Rhoades and Horton (1990) that given that many consumers have negative attitude towards root crops, intellectuals and Government has often down-graded importance and most researchers have ignored them, one might conclude that root crops are of little economic and nutritional importance.

Lack of extension programmes

Even in state like Kerala in which historical evidences mark cassava as saviour of millions of people during the worst famines witnessed elsewhere in the country during 1943 and where not even half of the rice requirements are produced locally, did not get its due share in the Govt's development programmes (Ramasundaram *et al*, 1996). In India only a few states had limited development programme on cassava like Tapioca package programme in Kerala during 1977-81 (Ramanathan and Anantharaman, 1991), adaptive trials and demonstration of high yielding varieties of cassava (HYVC) in Kanyakumari district during seventies (Ramaiah, 1979), popularisation HYVC in hilly regions of Salem district during eighties (Guruswamy and Kaliamoorthy, 1986) and cassava development scheme in Andhra Pradesh during 1993-94 (Rao, 1993). The high level committee on land and water resources appointed by Government of Kerala identified the following constraints to increase the output of cassava .1) prevalence of low yielding varieties 2) lack of awareness of improved practices 3) use of uncertified diseased planting materials (George, 1989), which speak of the extent of lack of extension support to cassava production. As a result there exists lack of functional linkage between research and extension. Lack of schemes did not permit extension machinery for programmed intensive technology transfer including multiplication and distribution of HYVC seed materials and communication of information through various extension methods.

Marketing

There is no regulated market or market federation for cassava, which leave the farmers at the mercy of contract merchants or carrying out the job by themselves.

This phenomenon does not spare completely even the states of Tamil Nadu and Andhra Pradesh known for assured marketing to industries where traders have a big say in price fixation. Further, there is no price support or guaranteed price fixed for cassava unlike that of cereals or cash crops. However, it is a matter of solace that there was Government intervention as far as Tamil Nadu is concerned on marketing of cassava processed products like starch and sago through Sagoserve, a success case in cooperative sector. The natural phenomenon of early perishability and the bulky nature of tubers further add to the problem of marketing.

Wage and price structure

There existed disproportionate increase in the labour wages and tuber price. The daily wages of agricultural labourers in India, especially in Kerala has registered an increase of three times during the last decade; the change in tuber price has not increased correspondingly. It is a fact that the labour requirement for cassava is relatively more accounting for more than 50 % of cost of cultivation (Pal et al., 1992). It may be pointed out that the steep increase in the price of the fertilizers also adds to the production cost. The stabilized productivity of cassava despite the increase in labour wages and input prices discourage the cassava farmers.

Lack of information base

Authentic, minute and timely information on various aspects of major crops from production to trade of raw or processed products need to be made available. Such an information base is lacking very much in the case of cassava. There was generally found to be a lack of reliable data on the post-harvest utilization of cassava in India (Baulch, 1989). Except the publication of data on area and production, sources of authentic information on product and trade are next to nil, which are however essential in prioritising research agenda and policy-making.

Poor resource base of the farmers

Cassava farmers, a majority of whom belong to small and marginal category with a poor resource base are neither organized nor have any strong forum or association to put forth their voice before the policy-makers. There are strong lobbies for other crops namely rubber and coconut (in Kerala), protecting their interest in support of the crop politically or otherwise, which is absent in the case of cassava. The poor socio-economic base of cassava farmers also act as an impediment in the adoption of appropriate technologies for augmenting the productivity.

10.3 Opportunities

Role in food security

Cassava has vast production and processing potentialities and this could be translated into opportunities in spite of many odds faced by it. Even though there is a change in the food habits of people pushing cassava as a secondary food crop due to availability of rice which has come down drastically may not dip down further as per the trend observed in last few years. However, the role of cassava as a secondary food crop has to keep pace with the increasing population demands. The growth rate of primary food crops like rice and wheat may not be able to cope up with the demand of growing population considering the resources and potentialities of these crops. Cassava can easily fill in the gap in attaining the needed food target.

Scope for area expansion

Meeting the challenge of additional production, could be achieved by area expansion both under traditional areas by fitting in existing cropping system or by extending to non-traditional areas. The biological advantages like thriving well in marginal and rainfed conditions come in its favour for area expansion in the non-traditional regions of the country like Andhra Pradesh, Maharashtra, Gujarat, Orissa and Karnataka. The sequential cropping with rice involving cassava in lowland situations and as inter crops in upland either adjusting the juvenile phase or spacing of the plantation crops could increase the area in Kerala.

Product diversification

Cassava as such provides ample scope for diversification and value addition. There lies a vast opportunity for nontraditional uses of cassava in the form of value-added foods, animal feed formulation and production of starch, sago as well as commodity chemicals like citric acid, high fructose syrup etc.

It can exploit its opportunities in the area of convenience food for which greater demands are ahead in view of women opting for self-employment in various sectors.

Trade sources indicate that there is a demand for chips of one lakh tonne per month for export which is of course related to the competition from South-east Asian countries. The bye-product of starch factories, thippi and of cassava flour milling, bharada can be used as cost effective ingredient in animal feed formulations. The demand for starch and sago will also increase corresponding to population growth which put the requirement of these as 6 lakh tonnes by the end of 2025. The simplicity of sago and starch extraction put cassava in an one-up manship position than other sources which could be exploited for setting up units in non-traditional areas like Gujarat, Maharashtra and Northeastern states. Further, sago production is a monopoly of cassava in India, an ample scope ahead for this crop to meet the increasing demand.

10.4 Threats

Decline in area

It has been observed that there is a considerable decline in the area of cassava in India over last two decades. The cassava area which was 3.90 lakhs ha during 1975 has declined to 2.43 lakhs ha 1991 thus registering a negative growth rate to the tune of 5%. The major factors contributing to this situation are the increasing availability of cereals coupled with an organized public distribution system and crop preferences of farmers in favour of commercially more profitable and less labour intensive crops like rubber, coconut etc. The classic case is the phenomenal growth in area of rubber even in small holdings from mere 1.88 lakh ha during 1971 to 4.70 lakh ha in 1998-99 in Kerala. Similar is the case with coconut, which has displaced the cassava area considerably. The decline in area is also attributed to availability and preference for "high status" food commodities like rice, wheat etc. The major factor affecting the differential pattern of cassava consumption in rural and urban areas in Kerala include cassava's rapid post harvest deterioration, the increased demand for convenience foods and improved availability of rice (Baulch, 1989).

Product-cum-price competitiveness

Cassava faces stiff competition from other sources of starch crop like maize in the price as well as the preference for the processed product. Starch and sago are major processed products of cassava manufactured mainly from 1000 small-scale factories of Tamil Nadu and Andhra Pradesh and also three large-scale factories in Tamil Nadu and Andhra Pradesh. There are nine large-scale starch factories mainly using maize and sorghum and very rarely fresh and dried cassava. The major reason for preference towards maize and sorghum is the relative advantage in price of these crops produce over cassava. Dried cassava is costlier than sorghum and maize to the tune of 60-70 and 70-90% respectively. The application of starch includes textile sizing and finishing foodstuffs, adhesives, modified starch and sweetners. Although cassava starch has specific advantages especially in hard printing of textiles, adhesives etc. maize starch is mostly preferred for other applications. However, it was observed that thippi, a by-product of cassava factories are used as filler in the feed formulations. Dried cassava chips may be used as a source of energy in compound poultry feeds, but most of the feed companies are reluctant to include cassava chips as an ingredient due to cost factor and competition from maize.

Competition in the exports

The bulky and perishable nature of cassava offer little scope in the export trade of raw tubers. However, there is an active international trading in chips and pellets and to some extent in starch and sago. Between 1956 and 1964 India was exporting cassava products (70,000 tonnes of dried chips per annum mainly to European countries. But it went out of export trade gradually after 1981-82 due to quota restriction imposed by European community (EC) and in view of the emerging export giant of cassava viz., the Thailand whose 90% of total cassava production is exported (Titapiwatankun, 1989) to EC. Thailand could forge ahead India in export due to low processing cost, export handling facilities and free trade environments.

11. Future strategies

11.1 Crop improvement

Intervarietal hybridization

a. Cassava mosaic disease resistance breeding

Resistance to CMD is being transferred from the exotic accessions *viz*., TMS 30001 (MNga 1), TME 3 etc. to indigenous varieties as the resistance to ICMV is not detected so far in indigenous germplasm. The resistant selections made are being field tested in disease prone areas to select location specific CMD-resistant varieties with higher starch yield. These varieties will be released and popularized for general cultivation by the farmers especially in Kerala and Tamil Nadu where CMD is the most important problem.

b. High starch varieties in cassava for industrial utilization

Selections made from recombinant lines developed from crosses of better combining and potential lines will be subjected to on farm trials in industrial areas with farmers' participation. High performing lines having stability in high starch content (more than 25%) and yield over different locations and seasons will be selected. The programme is meant for providing different cassava varieties to the farmers cultivating the crop under varying conditions of soil, topography and climatic conditions especially in the plains and hills of Tamil Nadu and in the red soils with lesser water source in Andhra Pradesh. The first 5 varieties released from CTCRI *viz*., H-226, H-165, H-97, Sree Visakham and Sree Sahya have been evolved under this programme.

c. High carotene lines in cassava for nutrient enhancement in rural areas

(International Network Programme with CIAT)

Cassava lines with high β-carotene (1000 to 2000 μg/100 gm) content, low cyanogens and good culinary quality derived from gene pool development and recombinant breeding programmes will be subjected to on farm trial with farmers' participation. The selections made will be released in those specific locations where the crop is used as a staple food by the rural people. Collaboration with international (CGIAR) organizations like CIAT, Cali, Colombia and IITA, Nigeria will be sought for funding the programme as well as popularization of the carotene rich varieties in countries in Africa and Asia where cassava is used as food in fresh and processed form as a staple. Two varieties *viz*., Sree Vijaya and Sree Visakham with high carotene content (650 µg/100 gm) were released from CTCRI these have to be popularised in the non-traditional and tribal areas.

Interspecific hybridization

Interspecific hybridization for protein enhancement in cassava tubers

(National Network Programme Proposed with NBPGR)

Cassava tubers are low in protein content (1-2 per cent) and interspecific hybrids are possible by crossing cassava with wild species like *M. tristis* having higher (4 per cent) protein content. Such hybrids will be back crossed with cassava for evolving varieties with higher root protein content and good culinary qualities.

Triploidy breeding in cassava for high starch varieties for industrial application

Triploids are produced in cassava by crossing colchicines-induced tetraploids and normal diploids. Triploid lines with high yield, high dry matter and starch content are being subjected to on farm trials with farmers' participation especially in areas where cassava tubers are used for starch extraction for industrial use. Potential lines with stability in starch content and better yield are selected based on on-farm standards and farmers/industrialists preference. The varieties will be released and popularized in the relevant areas for meeting the heavy demand of planting materials of high starch varieties in the industrial areas in Tamil Nadu, Andhra Pradesh and Maharashtra. Sree Harsha is the first triploid variety released (in 1996) with 38 per cent starch and @ 45 t/ha yield. This is the first report in the world in cassava on the successful application of polyploidy techniques for crop improvement in tuber crops.

Cassava True Seed Programme (CTS) for non-traditional areas

This programme was envisaged for the rapid production of planting material of cassava for the spread of the crop in areas where there was shortage of seed / planting material. The studies conducted so far has lead to the selection of a male sterile line, "Ambakadan" as the potential female parent for the production of cross pollinated seeds using the CMD resistant line TMS 300001 (MNga 1) as the pollen parent. Pollination block comprising these two lines planted in interspersed rows served as the seed production plot. The seeds are grown in the specific areas in the field during the cropping season. The seedling progeny was found to show normal tuber formation with an yield of 13-17 t ha^{-1} with minimum amount of variation in tuber characters which harvest did not affect its marketability or value.

Inbred lines in cassava for QTL mapping

(International Network Programme with CIAT)

Inbred lines are produced in cassava by repeated selfing of selected parental lines for 4-5 generations resulting in pyramiding of genes. The resultant progeny will be used for mapping of quantitative trait loci (QTLs), in cassava using specific markers. This programme is also being done with international collaboration with CIAT, Cali, Colombia since 2003. The basic studies will help in understanding the inheritance of quantitative characters and using it in targeted programmes for increasing starch content, modification of starch ad its commercial utilization to meet international market demand.

Short duration lines in cassava for inter cropping in rice based cropping systems

Short duration lines of cassava are popular in Kerala especially in the rice based cropping systems for which three varieties (clonal selections from indigenous germplasm *viz*., Sree Jaya, Sree Vijaya and Sree Prakash) have already been released in 1998. Hybrid lines with early bulking selected from resistance breeding programme are under field evaluation. They will be subjected to on-farm trials to evolve varieties having early maturity, high yield and culinary quality combined with CMD resistance.

National repository of tuber crops germplasm with facility for molecular characterization and long term storage of germplasm (IVBG)

The CTCRI is recognized as the National centre for conservation, regeneration and dissemination of germplasm of tropical root and tuber crops. Presently there are 4,011 accessions of different germplasm conserved in field gene banks. Part of this (800) has been conserved in *in vitro* active gene banks (IVAG). Facilities have been recently developed for **cryo preservation** and building *in vitro* base gene banks (IVBG). Collaboration with CIAT, Cali, Colombia, CIP, Lima, Peru etc. has helped in acquiring exotic germplasm as seeds and *in vitro* cultures. The programme has to be strengthened for carrying out studies on genetic stability, molecular characterization, disease indexing as well as creating **data base** on tuber crop gene bank. Networking is required with National and international agencies/ organizations for dissemination and exchange of materials and scientific information.

Exploration, collection, characterization and conservation of Biodiversity of tuber crops through National Network Programme with NBPGR

Exploration and germplasm collection are made from different biodiversity hot spots of the country like Andaman & Nicobar Islands, Western Ghats and Eastern Ghats. Repeated exploration and collection missions are planned to be conducted to these areas and other unexplored and potential areas of the country. Twenty three explorations and 360 collections of different tuberous species were made since the inception of the (NATP) programme from 1999 onwards. The entire programme is networked with the NBPGR and other crop based ICAR institutes, SAUs, State biodiversity institutions (TBGRI in Kerala) and Non governmental organizations like MSSRF. Documentation of passport data, accessioning of the collections with National gene bank at NBPGR, regeneration and multiplication of the accessions have been completed. Characterization of the 160 odd collections is in progress. The programme is conducted in mission mode (MM) approach and is aimed to make complete collection and inventorization biodiversity of tuberous species, including the crops and their wild relations. It is envisaged to inventorise the country’s diversity of root and tuberous flora, document the traditional knowledge, evaluate and record their utility in value addition. This will help in nutrient enhancement in the food baskets of the tribal and rural people.

Nutrient enhancement in cassava using Am A1 gene from Amaranthus hypochondriacus through National Network Programme with NCPGR

Cassava tubers are low in protein content though rich in starch and hence this programme is initiated with the aim of incorporating the protein gene (Albumin gene), Am A1, from the grain amaranth, *Amaranthus hypochondriacus* to cassava as has been done in potato. This is a network programme underway since 2002 with the National Centre for Plant Genome Research (NCPGR), JNU, New Delhi. It is expected to enhance the protein content of cassava which form a main part of the diet of rural poor in Asia and Africa.

Improvement of starch quantity and quality in cassava through biotechnological interventions

Cassava contributes a major source of raw material for industrial production of starch and starch derivatives like liquid glucose, high fructose syrup, dextrin, cyclodextrin etc. Besides, cassava starch is used in making sago, gums and biodegradable plastic. Chemical methods are presently used for the manufacture of these modified starches which cause a lot of environmental pollution and health hazards. This can be avoided when native starches with modified properties are made available among the cassava varieties. The basic biosynthetic pathway for starch synthesis in cassava is similar to that of potato. It involves a co-ordinated activity of ADP-Glucose pyrophosphorylase, starch synthases, branching enzymes and debranching enzymes. Corresponding genes for ADPGPPase, starch synthase and branching enzyme have been cloned and characterised from cassava. Transgenic plants in cassava expressing *E. coli* AGPase which is insensitive to regulation by P_1, – an inhibitor of AGPase - can increase the starch content. The amylase and amylopectin content of the starch can be regulated by using an 'antisense and sense (gene) construct' of GBSSI Genome (Starch synthase). Waxy starch cassava is of use in the manufacture of hi-value biodegradable polymers. Cassava varieties with starch having high amylopectin content are of use as thickeners, in pastes and glues and have a market with an unlimited growth potential.

Precise characterisation of germplasm using molecular techniques : Evaluating genetic diversity and elimination of duplicates in cassava germplasm using microsatellites, Isozymes and AFLPS

Redundancy in germplasm has to be avoided especially for the maintenance of large number of collections as in the case of cassava. Characterization of germplasm using isozymes and morphological traits has enabled the identification of potential duplicates. The duplicates can be identified in an efficient time saving manner through microsatellite and AFLP profiles. They can be further confirmed by way of physiological evaluation in the field and consequent removal from the core collection. This will help in reducing the cost (space, labour and duplication) of maintaining the collections especially *in vitro* Active and Base Gene Banks (IVAG & IVBG)

Strengthening conventional crop improvement programme using molecular techniques : Marker assisted selection (MAS) for resistance to biotic and abiotic stress and early maturity in cassava

(International Net Work Programme - CIAT)

Selection of desirable genotypes from a segregating population of a hybrid progeny is difficult besides time consuming. This is especially so in the case of heterozygous crop plants like cassava when selection is to be made dependent on expressed phenotypic characters alone. Selection done with the help of morphological markers my not be stable as the gene expression can vary according to environment. Morphological markers may also show tissue and developmental stage specific expression, pleiotropy and even at times, adverse effect on plant growth, vigour and viability. Molecular markers do not suffer from these limitations and thus offer advantages over the morphological markers. Screening efficiency in breeding programmes is increased because (i) the segregants can be scored/assessed at the seedling stage (ii) it is possible to screen for traits such as root morphology, resistance to races or biotypes of diseases, insects, nematodes as well as tolerance to drought and salinity. (iii) selection can be made for several traits simultaneously which is not possible by conventional methods. (iv) heterozygotes can be easily identified and distinguished from homozygotes without resorting to progeny testing. This saves time and efforts. Marker assisted breeding has profound effect in strategies like gene pyramiding for combining the effect of two or more genes conferring resistance against one or few pathotypes of any causal organism, thereby making the resistant character durable. Molecular markers for CMD resistance, root bulking and quality traits (QTLs) in cassava have been identified (CIAT, Colombia). Segregating population of large number of intervarietal crosses made between indigenous and exotic varieties available in the genetic improvement programme can be subjected to marker assisted selection for quicker identification of target characters and selections subjected to location testing with precision and accuracy.

Bioinformatics centre

Bioinformatics being identified as an area of high priority, programmes have been envisaged to set up a bioinformatics centre at the CTCRI. Initiatives have been taken to renovate an existing lab for use as an E-lab for Bioinformatics. To start with database is to be developed on germplasm collections of tuber crops, agronomic practices, pests and disease management, starch properties, extension activities and CTCRI publications. In future the centre will start functioning as information base in tuber crops biotechnology. It is aimed to implement provision for net working and linkage among tuber crop scientists, information and computer support services to the scientific community, to develop, support and enhance public information resources and build up software packages and databases specific to user needs.

Cassava varieties for leaf protein-an import substitution product for pet feed and cattle feed

Cassava leaves have high protein content (14-20 per cent) though the roots are low in protein (1-2 per cent). The leaves, after processing are used for protein enrichment of different feeds and have been found cheaper than the imported Alfalfa leaf protein. This is being utilized commercially in feed industry in Thailand and other Asian countries growing cassava for commercial use. Studies are in progress to evaluate the cassava germplasm for leaf yield and the protein turnover per hectare.

It is aimed to evolve breeding lines that can be used for dual purpose or lines with high protein yield that can be harvested throughout the season, thereby providing steady supply to the industry to bring down production cost for competing in international market.

11.2. Crop Production

Large scale production and distribution of quality planting materials of tuber crops

Cassava mosaic disease, taro leaf blight, viral diseases of sweet potato and yams etc. are affecting tuber crops production. Healthy planting material production is the back born for the development of the cultivation of tuber crops in various States. There is a large demand from the developments departments and farmers for healthy planting materials of cassava, sweet potato, yams, aroids etc. The minisett technology developed at CTCRI for rapid multiplication of planting materials has immense potential for the production of quality planting materials in tuber crops. The seed programme will operate to produce foundation seed materials of released varieties and disease free planting materials for distribution to state Departments of Agriculture and Horticulture for further multiplication and distribution to farmers. In order to ensure production of planting materials free of virus and similar pathogens, it is essential to do indexing prior to mass multiplication. The *in vitro* raised meristems will then be multiplied and transferred for hardening and subsequently transplanted under controlled conditions. Such plants will further be multiplied in the field using minisett technique. The programme also envisages training to Agricultural Officers, progressive farmers, women self help groups etc., on micro propagation and mass multiplication techniques as well as low-cost packaging for transportation of minisett plants. It is expected that with the dedicated efforts in this line, by the year 2020, all the existing diseased and unhealthy tuber crops could be replaced totally with healthy and disease free materials; it is optimistic effort.

Refinement of agro techniques in non-traditional areas

For sustainable production of cassava in non traditional areas such as Maharashtra, Gujarat, Bihar, Jharkhand, Chattisgarh etc., location specific production techniques have to be standardized or refined depending upon requirement.

Cropping systems research

Efforts to develop tuber crops based sustainable cropping systems with efficient resource use efficiency will be intensified. This involves conducting compatibility studies, standardization of agrotechniques and nutrient management and on farm testing. Suitable models for homestead cropping systems involving tuber crops will be developed. Systematic studies on intercropping tuber crops in orchards and allelopathic interactions will be taken up. Crop varieties suitable for various cropping systems will be identified and their production potential evaluated. This has special reference to evaluation of production potential of short duration, high yielding varieties of tuber crops in rice fallows and development of management practices to enhance their resource use efficiency. Detailed investigations on the feasibility of inclusion of short duration legumes as intercrops or as sequential crops with tuber crops is proposed. Profitability of growing aromatic and medicinal plants in association with tropical tuber crops will be explored.

Low input technology for tuber crops

Exploitation of genetic diversity for efficient resource use under low input conditions will be pursued. Standardization of low input technologies with emphasis on reduced levels of fertilizers, use of biofertilizers, green manures and organic manures will continue. Agronomic research to identify cheaper and efficient nutrient carriers will be strengthened.

Integrated nutrient and water management

Studies on utilization of industrial waste as nutrient carriers and development of integrated nutrient management strategies in the production of tuber crops are also proposed. Research on long term fertility management for sustainable production will continue. Nutritional studies in aroids and maximum yield research in tuber crops through systematic approach in fertilizer use are also envisaged. Influence of organic manures, secondary and micro nutrients on nutritional, processing qualities and pest and disease incidence will be studied. Modelling studies on nutrient dynamics and transformations will be undertaken. Environment friendly technologies for maintenance and improvement of soil productivity through soil and water conservation in sloppy terrains (eg. use of coir geo textiles) will be developed. Micro- irrigation and effect of mulching to economise water and nutrient input will be investigated. Scope of fertigation in tuber crop production will be assessed.

Organic production of tuber crops

Organic farming is the best alternative farming method, gaining relevance due to the growing awareness of health, environmental safety and quality foods. Tuber crops are grown neglected in homesteads and their yield levels are at present low. Though conventional agriculture results in higher yield it has negative impacts on food, soil, water and environmental quality. Tuber crops respond well to organic manures and there is ample scope for such an organic production. Currently research on organic farming in tropical tuber crops has not gained sufficient momentum. Development of technologies for the production of high quality tuberous vegetables with export value, apart from maintaining soil health and productivity as well as safeguarding the environment and human health are contemplated. Formulation of package of practices prescriptions for economic organic production and promotion of scientific organic farming in tuber crops are targeted.

Development of substrate dynamics and supply of micro and secondary nutrients

Continuous cultivation of tuber crops leads to exhaustion of essential elements, particularly micronutrients. An explicit goal of tuber crop production should be good human nutrition. Micronutrients play an important role in enhancing yield as well as improving quality and nutritional status of the tubers. Recent research by the USDA Economic Research Service (ERS) suggests that cropland should be efficiently allocated to meet nutritional ends. Studies will be carried out to delineate micro nutrient deficient areas, standardize the micronutrient requirements of tuber crops and to formulate suitable corrective measures for higher production in order to ensure nutritional security of the rural poor.

Rhizosphere engineering by blending all kinds of helpful bacteria

Development and use of biofertilizers for sustaining productivity will continue. Efforts for commercial multiplication of VAM, its storage and improvement of strains will be pursued. Plant Growth Promoting Rhizobacteria (PGPRs) are beneficial microbes, that are ecofriendly with a dual mode of action of growth promotion and disease suppression in plants. The potential of PGPRS in tuber crop production will be exploited.

Integrated weed management in tuber crops

Weeds are a serious menace in tuber crop production especially in low lands. The present practice of hand weeding is time consuming, labour intensive and involves drudgery. The magnitude of the problem is more serious in industrial areas, where heavy doses of fertilizers and intensive irrigation are resorted. In such areas studies to develop suitable mechanical and chemical control measures will be taken up. Apart from this integrated weed management practices in tuber crops involving cost effective eco friendly practices are also envisioned.

Precision farming of tuber crops

Precision farming employs the most modern gadgets in information technology for the efficient use of agricultural inputs viz., irrigation water, fertilizers and plant protection chemicals. The key components of precision farming are digital maps generated by Geo Positioning Systems (GPS) and computer aided monitors. Though the technology requires very high capital investment, the same can be employed for judicious use of nutrients and water, particularly in industrial cassava production belts. Hence precision-farming techniques will be tried in nutrient and water management to a possible extent.

Partial mechanisation of cassava cultivation

Presently cassava cultivation is not mechanised and field operations such as land preparation, breeding, drainage, harvesting etc involves drudgery, are tedious and time consuming. Hence development of suitable agricultural implements or machinery for land modulation, deep drainage and other farm operations for cassava production in industrial areas is imperative.

Abiotic stress management in tuber crops

Screening of tuber crop varieties for drought tolerance and detailed studies on physiological and biochemical mechanisms imparting drought tolerance will continue.

Investigations on the physiology of tuberization and starch synthesis will be undertaken.

Hormonal changes and relations with tuberization will be studied in depth.

11.3. Crop Protection

Field and storage pest management

The programme envisages identification of biotypes/races in major pests, nematodes, viruses and fungi, damaging tuber crops both in field and in storage, characterization based on the basis of biological, serological, molecular and electron microscopy techniques, biotypes of insect pests/nematodes of economic importance, strains/races of viruses/fungi of economic importance.

Epidemiology/population dynamics of major diseases and pests

In order to develop models and forecasting systems it is proposed to study the epidemiology (incidence and intensity) of major diseases and pests and develop statistical models, disease forecasting system and disease maps.

Studies on virus vector relationship

Virus-vector relationship of important viral diseases to be investigated with modern biotechnological tools and techniques. This would help in the disease epidemiology investigations and developing forecasting systems. The study includes host associated Virus –Vector relationship in major economic important diseases like ICMV, SLCMV, serological and molecular confirmation on Virus-vector relationship, vector population dynamics and developing statistical models., effect of endosymbionts on vectoring of viruses of major diseases.

Pest and disease resistance through biotechnology

Identification of resistant crops and development of induced resistant crops/ transgenic crops in tuber crops against major pests and diseases like ICMV, SLCMV, and others, identification of resistant lines/hybrids against major pests, nematodes and diseases, development of induced resistance in tuber crops against major pests and diseases especially cassava tuber rot, development of transgenic cassava against ICMV/SLCMV, etc.,

Molecular diagnostics for virus

This programme envisages development of molecular diagnostic kits for major economically important viruses infecting tuber crops especially for ICMV, SLCMV, etc, development of serodiagnostic methods and kits for major economically important viruses infecting tuber crops especially for ICMV, SLCMV Viruses, development of nucleic acid based detection methods & field kits.

Developing biopesticides (bioinsecticides, bionematocides, etc) from the tubercrops

This proposed programme includes isolation of biopesticides from cassava, bioassay on insect pests of national importance and nematodes, leading to their use in ornamental horticulture and crop pests mammalian toxicity of the biopesticides, field/warehouse evaluation of biopesticides, integration of biopesticide with synergist/or other ecofriendly chemicals for enhanced bioefficiency, bioassay of the formulation and field/or go-down evaluation, isolation of the active principles from the plants and bio-efficiency evaluation on insect and nematode pests, biosafety/mammalian toxicity studies, development of effective formulation of the biopesticides, field and go- down evaluation.

Eco-friendly management of pests and diseases

Studies will be continued on the biocontrol agents such as parasitoids, pathogens and EPN of pests, nematodes and diseases of tuber crops, against insect pests, nematodes and pathogens of other crops of national importance, Whitefly, mealybugs and chips borers, antagonists of tuber rot, EPN on insect pests.

Bio-intensive pest and disease management

This programme includes the development of substantiable biointensive pest / disease Management technologies against major pests, nematodes and diseases of tuber crops occurring in field as well as under storage, with more emphasis on behavior modifying tactics, biological feasibility of integration of parasitoids, pathogens and nematodes, with biopesticides, investigation on the integration of pheromones, kairomones, allomones and synomones with other components of pest management, long term effect of behavior modifying tactics in the IPM/IDM, biological and semiochemical management of pests and diseases in the stored tubers.

Establishing plant quarantine units

Plant Quarantine is especially important in the context of WTO/Liberalization of trade policies, hence, survey and surveillance on the incidence of insects nematodes and diseases of tuber crops which are economically important and of exotic origin, survey on the outbreak of pests and diseases, quarantine the economically important exotic pests and diseases especially while importing tubers, vines/stems etc. will be taken up.

Commercialization of pest / disease control agents

Under this programme efforts will be made to produce the biocontrol agents like pheromones, parasitoids, EPN, biopesticides, diagnostics kits etc. and popularise and commercialise the technologies. The IPR/patenting issues will also be taken care of under this programme.

11.4. Crop Utilization

Value added products and their commercialization

The technology for the manufacture of value added products for food, feed and industrial uses has been perfected at CTCRI during the last three decades. Efforts have been made to popularize the food production technologies through *in situ* and outreach training programmes. Technologies like starch based biodegradable plastics, alcohol from cassava low cost biotechnique for making fermented cassava flour have been patented. The CGIAR Vision Statement to the year 2020 (Scott *et al.*, 2000) visualizes that by 2020, roots and tubers will be integrated into the emerging markets through the efficient and environmentally sound production of a diversified range of high quality, competitive products for food, feed and industry'. IFPRI's IMPACT simulations indicate a growth rate of 0.76% per year by 2020 in India, for cassava has been projected. Other food applications of the native and modified tuber starches include use in weaning food formulations, ice cream mixes, instant pudding mixes etc. which is also a new research focus initiated at CTCRI. The patented technology for alcohol production from cassava has to be refined, in the new scenario of increased use as biofuel. It is necessary to economise the process by using efficient mutant strains of yeast, cheap indigenous sources of hydrolytic enzymes, use of immobilized enzymes etc.

The additional projected demand on processed foods indicates a concentrated effort on developing newer and innovative food products from nutritional as well as health angle from tuber crops. A whole range of extruded food products with greater customer appeal is also proposed to be developed using a New Food Extruder (Brabender make), which can create export opportunities as well. Diversification of tubers for food products is also envisaged in the context of WTO, wherein the import of starch from countries like Thailand may pose a threat to the starch factories of Tamil Nadu. Similar to plastics, detergents based on petro chemicals are causing a major threat to the environment. Eco-friendly detergents, which are safe for the hand, clothes and the environment are the need of the hour and these can be made from tuber crops starches, by suitably modifying the starch structure. Starch and its derivatives can function as source of bio detergents. Starch esterified with long fatty acid chains or wholly glucose esters are considered the future classes of detergents. This is an innovative research to be initiated at CTCRI.

Most of the synthetic adhesives contain carcinogenic chemicals and in the context of the greater awareness on such products, it is desirable to develop starch based adhesives which are perfectly safe from the health angle.

Textural and rheological characteristics of tuber crops and their flour based mixes decide the quality of the value added / extruded food products made from them. The relationship between texture and the physico-biochemical properties of tuber crops as well as the rheological behaviour of composite flours based on tuber crops have to be studied to facilitate new product designing. The consumer acceptability of the convenience food products depend to a large extent on the textural characteristics.

Composite flour technology for tuber crops

The importance of functional foods and designer foods is being increasingly realised round the globe, due to their ability to counter act specific disease like cardiovascular disease, cancer, obesity, diabetes etc. The tuber crop flour / starches have distinctly varied functional properties, which enables fortification with cereal and / or legume flours, fibre additives etc. to make composite flours with desired effects. Although composite flour technology received attention in the western countries in the 1980s onwards, this is a much less studied area in India. The availability of a number of edible varieties of cassava makes possible effective blending and their rheometric and farinographic studies to enable the selection of the best possible combinations leading to tailor made flours for end uses.

Establishment of post harvest technology units

During the past five year plans, a number of technologies have been developed for the efficient post harvest management and utilization of cassava. Setting up of units for the effective demonstration of such technologies, storage of farm produce, utilization technologies for value addition, packaging units with modern packaging facilities etc. will enable rapid dissemination of the technological knowhow, leading to efficient commercialisation of technologies. The meeting of the Sub-Group on 'Horticulture and Protected cultivation' in New Delhi on 17 July, 2006 also necessitated the starting of such PHT Units during XI Plan.

Post harvest deterioration of cassava

The most important post harvest problem affecting the utilization of cassava tubers is the rapid spoilage from physiological processes within the tubers and microbial spoilage. The research world wide has shown that although varietal differences in the deterioration rate are evident, there is no variety totally resistant to the rapid post harvest spoilage. This necessitates processing the tubers into sun-dried chips, which has a better shelf life. However, high labour involvement, spoilage of dry chips by insects and microbes, discolouration of starch and sago made from sun-dried cassava chips etc. are issues that necessitate varieties with better shelf life in the fresh state and can be processed within a reasonable time to starch. Research conducted in India and elsewhere has shown that oxidative reactions trigger the decay process and maintaining partially anaerobic conditions can enhance the shelf life of fresh tubers. Further, the enzymes like peroxidase, polyphenol oxidase, catalase and superoxide dismutase have role in the decay. Understanding the pathways of deterioration reactions and arresting the action of the oxidative enzymes is one way by which the post harvest deterioration can be controlled. Blocking the pathways through biotechnological means is visualized to result in varieties with better shelf life. It is necessary to focus in this area to unveil the mechanism of rapid post harvest deterioration of cassava and evolve genetically engineered plants with better shelf life for tubers.

Diversification for pharmaceutical sector through extraction and characterisation of phytochemicals

The large spectrum of variability available among the different tuber starches makes it a potential candidate for the pharmaceutical industries. Native and modified starches can find use in tablet and capsule making. Cold water miscible starch made from cassava tubers, besides textile use, can also find application as a food thickener, in shampoos, body lotions etc.

Addressing the problems of starch and sago industries

The importance of cassava as an industrial raw material for the production of starch and sago is being increasingly recognized in India. The resurge has come in view of the scope of alcohol as biofuel and the projected demand in the paper and textile industries. The challenge in the context of WTO necessitates the production of quality product conforming to International standards, to compete in the domestic and global markets. In this new paradigm shift in utilization, the problems faced by the starch factories like poor extractability of starch from tubers especially sweet potato, poor colour of starch and sago, poor water use efficiency, non-availability of tubers round the year, environmental pollution threat from liquid and solid wastes etc. have to be addressed in a realistic manner and solution evolved to enable the industrialists to sustain the factories. Some of these items have been attended in the NATP operating at the Institute as well as through extra-mural projects. These specific problems were also recommended to be studied in depth by the QRT (1997 – 2002) of the Institute. The exploitation of the farmers by middleman / factory owners is an often highlighted issue, as the starch content is normally assessed from the breaking / biting strength of tubers, except in a few factories where specific gravity balances are used. This hinges on the need to develop electronic devices for *in situ* starch determination and this research has almost reached the goal. The unit has to be refined for better sensitivity and wider adaptability to all tuber crops and field tested further for rapid dissemination.

Byproduct utilization of Thippi

Thippi is the solid fibrous waste discharged from the cassava starch factories, which contains around 55 per cent unextracted starch. It is a major pollutant to the flora and fauna. Being a starchy low cost product, this can be used for the economic production of commodity chemicals like ethanol, liquid glucose, high fructose syrup, industrial enzymes like a-amylase, amyloglucosidase, glucose isomerase etc. Incorporation of thippi in fish feed is another innovative area, where collaboration with Fishery Institutes can help in a big way to perfect the feed production technology.

The use of thippi for particle board manufacture is another area of research, which can widen the utilization prospects of this low cost material.

Storage pests and management

Survey carried out in cassava chips storing godowns in Kerala revealed that the chips are infested by around 21 insects. Due to the infestation, chips are turned into a powdery form and lose their nutritive value for food or feed and lead to discolouration of starch, when used for starch extraction. *Araecerus fasciculatus*, *Dinoderus bifoveolatus*, *Rhyzopertha dominica*, *Sitophilus oryzae* and *Tribolium castaneum* are the most important among them. Detailed studies on the biology and bionomics are warranted on these insects. It is also necessary to devise safe storage techniques to prevent the infestation.

Minimal processing of fresh tubers

Fresh tubers are presently exported from India to Gulf Countries, Europe and USA and demand increases in areas where the Indians are concentrated. Competition exists from Pacific Ocean islands and Carribean. Nevertheless, the transport losses are very high due to long transit time, susceptibility to microbial damage, space needed due to the bulky nature etc. Minimal processing is usually done for vegetables to ease packaging and transport of the materials. Technologies standardized for tuber crops can certainly help in enhancing the export prospects and ensuring movement to various states in India. Research in this direction has been initiated at CTCRI, based on the demand from exporters and also the suggestion of RAC and has to be taken further to perfect the technology.

Modifying starch quality through biotechnology

Starch with different functional properties are required by the industry. Use of modified starches is not desirable since chemicals used for modification are often toxic and not permitted. So it is desirable to bring about modification in starch properties by use of biotechnological methods. The modifications include (1) low or high amylose starches for use in food and industries (2) starch with altered chain length for improved functional properties (3) starch with higher phosphate content for food thickening application (4) starch with b-linkages to improve stability and providing 'resistant starch'. The 'tailor made' starches, can help in enhancing the utilization potential of cassava, as the extracted starch with the desired properties can directly find access to industries.

Nutritional security from tuber crops

Although information is available on the nutritional profile of a few varieties of cassava, The vast bulk of information on the diversified germplasm is yet to be collected. The hidden wealth of nutrients in the germplasm, the modification / changes undergoing during processing, potential of alternate parts like leaf, vines and stalk of crops etc. have to be unveiled through more studies. The cultural as well as climatic effects affecting nutrition also need to be investigated.

Phytochemicals / Nutraceuticals / Anti-nutrients in tuber crops

Many of the tuber crops are rich sources of minerals, vitamins, amino acids, etc. Secondary metabolites like cyanoglucosides in cassava have been studied to varying levels in India and abroad.

Biochemical mechanisms of drought tolerance in tuber crops

The biochemical response to water stress has been studied cassava and some basic information regarding the biochemical changes associated with drought stress are currently available. More studies on the metabolites accumulated during water stress as well as on the protein profile to identify the nature of stress proteins and their role in stress tolerance. Identification of molecular markers for stress tolerance, is another aspect of research, which can lead to genetically engineered plants having drought resistance.

11.5 Social Sciences

Participatory technology development (PTD) through farmers participatory approach

Despite the research system generating useful technologies for adoption by the user system, many are not suited for different production system due to lack of understanding of farmers situations, resource availability needs and aspirations of farmers operating under different socio-economic and cultural background. This baffling situation emerges mainly due to a **mismatch between scientists' perceptions on farmers' preferences and the farmers' expectations and needs**. Hence, the farmers' participatory technology development becomes and need of the hour to rectify this defect in developing technologies suiting to varied micro niches, needs and resources of the farmers.

Giving due importance to the FPR approach, CTCRI has already initiated farmers participatory programmes especially for varietal selection in early nineties. This has paid rich dividends in identification of two short duration high yielding cassava varieties, Sree Jaya and Sree Vijaya which were formally released for cultivation in

Kerala during 1998. Thus, participatory technology development is one of the thrust areas in the next 15-20 years to generate appropriate location specific tuber crops technologies.

Testing and popularization of cassava technologies in non-traditional/ tribal and remote areas

Owing to the gradual decline in area of tuber crops especially cassava and sweet potato, especially in the traditional belts of Kerala, Tamil Nadu etc., the vast potentiality existing in non-traditional regions for the cultivation of tuber crops should be effectively tapped with the active collaboration of development departments, voluntary organization, self help groups etc., exploratory studies are proposed to be undertaken in states like Karnataka, Maharashtra, Gujarat, Madhya Pradesh, Charkhand, Chhattisgarh etc. to identify the potential areas for expanding the cultivation and utilization of tuber crops. Subsequently location specific varieties and agro-techniques, will be identified through adaptive research trials in farmers' field. It is also contemplated to take up large scale extension efforts involving demonstrations, field days, exhibitions etc. for speedy dissemination of technologies.

In majority of the tribal settlements of India, tropical tuber crops are important crops which enable their livelihood. Likewise, in the poverty stricken remote areas, tuber crops, owing to their wide adaptability to diverse soil and climatic conditions, can be a best fit to save people from hunger. Hence, it is of paramount importance to assess tuber crops technologies in such areas and undertake effective transfer of such technologies, that are found suitable.

Development of information and communication materials on cassava

The merging information and communication technologies have immense potential in tuber crops extension and training. With their abilities of interaction, demassification and asynchronization, they define the modes of human communication. Hence, there is an urgent need to develop appropriate applications of information communication technologies in tuber crops extension and training. The programme envisages preparation of leaflets, pamphlets, multimedia communication system including video films, slide stories, radio programmes, information retrieval services through CDROMS and agriculture research information systems (ARIS).

Development of seed villages for cassava

Lack of availability of quality planting material in tuber crops continues to remain as a **major stumbling block** in the mass scale transfer of improved varieties of cassava. As these group of crops suffer from the inherent weaknesses of slow rate of multiplication, bulkiness, rapid scale multiplication to cater to the demand for them is rather found very difficult. Moreover, problems in bulk transport of material from the place of multiplication to the places of cultivation also pose a great challenge. The QRT (1997-2002) of CTCRI has strongly recommended the **concept of seed village** to tide over this situation. Hence, during the coming 15-20 years, in major cassava growing regions of the country, appropriate locations and cooperative farmers will be selected for developing cassava seed villages and these will from the major source of planting material production in future.

Farmers field schools in cassava

When most of the extension machinery engaged in transfer of technology are struggling to solve the problems of non-adoption of certain improved technologies, other organizations have experimented technology generation and extension models that differ from conventional approach emphasing the need for the target group participation. Farmers Field School (FFS) is one such approach different from the normal extension approach which pins importance on farmers participatory training and information/technology generation. Experiences in several Asian countries over more than a decade have indicated that plant protection measures, and implementation through Farmers Field School was very effective FFS is a field based learning process within a group in which farmers share experience and try to find solutions to their problems where field extension worker is a facilitator. Under the Indian conditions quality planting material production and value addition are two important aspects that have to go into farmers' training programmes in order to equip them with the necessary technical knowhow. Taking advantage of the FFS approach, it is contemplated to use FFS for rapid diffusion of plant protection technologies and strategies amongst cassava farmers.

Capacity building of cassava clientele system

The importance of capacity building for human resource development has assumed all the more significance in the context of the changing agricultural scenario from subsistence to surplus/commercial agriculture and from development centered around production and productivity to that of efficiency and sustainable development. Cassava is no exception to this. CTCRI being the only of its kind in the world doing research exclusively on tropical tuber crops has generated a volume of production and utilization technologies. It is also engaged in the process of developing more such technologies taking into account the changed scenario and WTO agreement etc. These technologies should reach the clientele system beginning from farmers, farm women, tribes, rural youth, extension personnel, small entrepreneurs, industrialists, women self help groups etc. CTCRI also has the expertise to cater the needs of international personnel in imparting knowledge and skill on various aspects of tuber crops. In view of this, capacity building activities will be taken up on a continuous basis in the coming decade to equip the different clientele systems of tuber crops with latest knowledge on these crops.

Total factor productivity and impact assessment of research investment on cassava production technologies

Total factor productivity (TFP) measures the amount of increase in the total output which is not accounted for by increases in the total inputs. The TFP trend indicates whether production growth is taking place in a cost effective and sustainable manner. The TFP on cassava is not yet worked out in India. An attempt will be made to study the TFP of important tuber crops like Cassava in India.

Illustration of how the technologies are serving the society by raising income, employment, food and nutritional security and export, will help the research managers and policy makers to prioritise the researches in the wake to dwindling resource crunch.

Commercialisation and costing of cassava technologies

Techno-Economic feasibility report act as a base material for any entrepreneur to venture a new project/industry. CTCRI has been developing many technologies for producing value added products from tropical tuber crops for the past three decades. Commercialization of viable technologies is an important aspect after developing the technologies. Preparation of TEFR will serve this purpose.

A large number of training programmes both at the Institute and at outreach locations are conducted for the benefit of women Self Help Groups, NGOs, Kudumbasree (Kerala) units etc. Training is routinely offered on food production technologies, processing equipment and industrial technologies, to Agricultural officers, assistants and farmers under programme sponsored by the Regional Agricultural Technology Training Centre (RATTC).

A Consultancy Processing Cell is in operation at the Institute, with five members and is directly associated with the commercialisation of the technologies developed.

Research prioritisation based on market driven approach

Research resources are allocated by informal mechanisms such as collective judgments or beliefs of individual scientists, historical precedents etc. The public sector is being held accountable for the utilisation of increasingly scarce public funds, it is the need of the hour for using more systematic and objective approaches to allocate research resources. Prioritization of research in cassava based on the direction given by market demand driven approach is the need of the hour, in the context of the global scenario and WTO. The research programmes will be prioritised based on the suggestions of RAC / SRC as well as the information from the market demand assessment.

Livelihood security analysis of tuber crop farming communities

The concept of sustainable livelihoods is increasingly important in the development debate, poverty reduction and environmental management. Initial assessment of the tuber crop farming communities will be made through livelihood security analysis and the information on nutritional, social, economic security of then farming communities will be generated. This will enable the researchers and planners to take up programmes involving tropical tuber crops and their value added products for enhancing their food/nutritional security, increase the standard of living by increasing the source of income generation.

International trade studies

International trade of tropical tuber crops and their value added products is picking up especially after the initiation of economic reforms in the form of liberalization and globalization. Due to WTO agreement, India has to open its market for the international good from 2005 onwards. In this context, studies on comparative advantage of other commodities from cassava in the international trade will be taken up.

Crop growth models involving tropical tuber crops

Slow advancements in the research and development of tropical tuber crops aggravate poverty in many poor countries. Achieving higher productivity in shorter time only can solve this problem. Simulation model is a helpful tool to tackle the situation. With the help of computer the growth of crops can be studied. Number of trials can be conducted without spending the enormous amount of resources and time which are otherwise required for field experiments. Different soil and weather conditions can be simulated very easily and the performance of the crop under these varying conditions can be studied easily and quickly. In this context, studies to develop growth models of tropical tuber crops have already been initiated at CTCRI in cassava.

International training facility

During the past four decades of existence, CTCRI has developed a large number of production and utilization technologies for tuber crops, the beneficiaries being farmers, researchers and progressive entrepreneurs. The Institute have been organising national and international training courses for disseminating and updating the technological knowhow. However, lack of an international training facility at the institute is an impediment in the technology transfer. The IMC, RACs and QRT of the Institute have recommended the creation of such a facility at CTCRI. Demand from SAARC, Africa and even Latin American countries to take up training at CTCRI has also necessitated the creation of ITF. The necessary infrastructure for this has to be set up for starting the training programmes.

Empowerment of women and gender issues

Adequate emphasis is given in the perspective plan in developing programmes for the empowerment of women in agriculture. Training for the Self Help Groups, NGOs, women farmers etc. on cultivation and utilization aspects of tuber crops is planned to equip them with modern production technologies and for their capacity building to start agri business ventures based on tuber crops. Gender issues are also given thrust under the Institution Linkage Programme (IVLP), where several programmes have been started for the benefit of the women farmers. The Government of India has asked for separate budget on this programme, indicating the increasing importance given to it.

11.6 AICRP on tuber crops

Germplasm collection

The programme envisages collection and evaluation of cassava germplasm in the region especially with economically traits, maintenance of germplasm at different centres, identifying cultivars/accessions with economically important traits including yield, tolerance to biotic and abiotic stresses, act as National Active Germplasm sites for cassava at different zones of India

Identification of varieties / hybrids suitable for various agro-ecological zones

This programme comprises developing suitable hybrids/varieties of cassava apt for the region, development of short duration varieties suitable for the region with economic traits, identification suitable varieties for North Eastern and Eastern India, Developing high beta carotene cassava varieties and wherever vitamin 'A' deficiency is a problem, sharing promising varieties among the different centres for research work.

Production technologies for cropping systems and zones

Emphasis will be given under this programme for developing appropriate agro techniques utilization, organic farming for optimizing the tuber production, exploring organic sources of fertilizers in cassava and organic farming, identifying suitable package of practices for cassava suitable to the zone, intercropping in cassava and cassava as intercrop in orchards, utilization of biofertilizers in cassava, cassava based cropping system for each zone.

Pest and disease management strategies

The pest and disease management strategies envisaged include survey and surveillance of pests and diseases of economic importance, identification of tolerant/resistant lines of major pests and diseases, bio-intensive IPM/IDM for major pests and diseases, including resistant/tolerant lines/variety, bio-control agents etc.

Farm outreach programme

Technology dissemination for cultivation and utilization of tuber crops is the objective of this proposed programme and includes popularisation of cassava through farmers meet, seminars etc., dissemination of knowledge on the utilization aspects of cassava, organizing supply of healthy planting materials of cassava through the centre in liaison with the State Agriculture/Horticulture Departments/KVKs.

Networking research among the different centres

An effective networking of research among the various centres is proposed to avoid duplication in germplasm conservation, multiply and provide healthy planting materials, testing of varieties / hybrids etc.

Post harvest utilization

The potential of cassava as poultry, pig and fish feeds well as cassava leaf for silk worm raring will be studied.

Communication and transfer of technology

Creating awareness about the production and utilization of tuber crops is important to ensure social and economic security of the people engaged in the cassava cultivation in the North-eastern region. So with this mandate impact assessment of cassava research for the development of North-eastern zone as well as multi media training module development will be taken up.

Quality planting material production

Expansion of cultivation depends largely on the availability of healthy planting materials. Hence adequate thrust will be given for quality planting material production through rapid multiplication techniques, *in vitro* techniques etc. Development of seed certification standards will be also be taken up under this programme.

(Information on future strategies was sourced from Divisions of Crop Improvement, Crop Production, Crop Protection, Crop Utilisation, Sections of Social Sciences and AICRP on tuber crops)

12. Summary and conclusions

Globally cassava is grown in an area of 17.57 m ha producing 189.09 million tonnes with a productivity of 10.76 t/ha. India accounts for 1.54 per cent of world's area and 3.75 per cent of world production of cassava. India acquires significance in the global cassava scenario due to the highest productivity in the world (26.30 t/ha).

Cassava production is concentrated in the southern peninsular region of the country owing to its favourable climate and its efficient utilisation commercially. Kerala has the major share in cassava area and its production is mostly used for human consumption. Thiruvananthapauram, Kollam, Malappuram and Kottayam districts produce more than half of the cassava production in Kerala. Eighty per cent of the cassava produced in Tamil Nadu is utilised industrially to produce starch, sago and other value added products. Salem, Kanyakumari, Dharmapuri, Namakkal, Erode etc. are the major districts producing cassava in Tamil Nadu. East Godavari district is the major producer of cassava in Andhra Pradesh and the production is used in the production of sago, chips, flour etc.

Cassava area in India over a period of time recorded –0.78 per cent annual compound growth rate (CGR) while that of productivity recorded 0.75 per cent CGR both being statistically significant. Though production of cassava in India revealed a declining trend, this was not statistically significant. This is in spite of the significant decline in trend in area and production of cassava in Kerala since 1975-76.

Cassava is cultivated as mono crop as well as inter crop in coconut, banana, mango, rubber and cashew plantations across the country. Vegetables such as cucumber and ridge gourd and groundnut and cowpea are being cultivated as inter crops. Cultivation practices are different in different states under different cropping systems. Maximum cassava area is in low land and irrigated conditions in Kerala and Tamil Nadu respectively while rainfed cassava area is more in Andhra Pradesh.

Though cassava production centres are concentrated in the southern India, marketing centres are distributed throughout the country for different value added products from cassava. Cassava and its value added products are marketed in three different sectors viz., Human consumption market, animal feed market and as commercial products. Maximum production in Kerala is consumed as staple food. Sago is consumed in preparing many items like *Payasam, Kichidi, Uppuma, Bonda* etc. in Maharashtra, West Bengal, Tamil Nadu and Andhra Pradesh. Starch, sago, chips, flour are the major commercial products from Cassava. In the animal feed market, *thippi* and peel flour are used in the preparation of concentrate feeds. Middlemen usually exploit the traders and processors and hence dominate the trade. SAGOSERVE helped in partially eliminating the domination of middlemen in sago and starch trade in the country. It is the only organised set up to help and protect the processors especially in Tamil Nadu.

Technologies developed in various fields such as development of new varieties, value added products, standardisation of agro-techniques and plant protection measures helped in sustaining the crop with the world's second highest productivity. CTCRI has noteworthy contributions in many areas.

Early maturing high yielding cassava varieties like Sree Prakash, Sree Jaya and Sree Vijaya are available in addition to already popular varieties like H-165, H-226.

Agro-techniques are standardised in different cropping systems. Alternate technology for the production of disease free planting material of cassava through nursery techniques helped in ensuring the availability of disease free planting material. Integrated disease management practices were developed which successfully contained the diseases in cassava. IPM programme to manage the storage pests on cassava were developed.

Technologies developed have been transferred through many programmes like National demonstrations during 1970-74, Operational Research Project (IDRC funded) during 1976-80, Lab to Land programme during the eighties and the world Bank aided Institution Village Linkage Programme since 1996 and still continuing. The CTCRI offers consultancy to large scale farmers and entrepreneurs thereby transferring the production and processing technologies. Many technologies diffused successfully through effective TOT programmes over the years.

It is estimated that currently 3.3 million tonnes of cassava in human consumption sector, 1.5 million tonnes of cassava in Industrial sector and 0.9 million tonnes in animal feed sector is being used. Supply projections indicate that by 2020 A.D. cassava production in India may be about 6.58 million tonnes. Cassava area in Kerala will come down due to shift in consumption pattern of people from low value foods like cassava to high value foods like cereals and also due to shift in cultivation of more economical plantation crops by farmers. Area expansion is future is possible in the industrial zones of Tamil Nadu and Andhra Pradesh.

Projected demand for cassava in 2020 A.D based on per capita availability will be 9.6 million tonnes while it will be 9.3 million tonnes based on expected development in different sectors.

The demand and supply projections indicate that by 2020 A.D, the potential demand for cassava will exceed the potential supply by 3.047 and 2.758 million tonnes. This gap can be bridged by expanding the cassava area in non-traditional areas and productivity improvement in states like Andhra Pradesh and bringing more area under irrigation.

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Annexure

1. Starch: It is a group of polysaccharides, composed of glucopyranon units joined together by a - glucosidic linkages
2. Sago: It is a processed edible starch available in the form of small globules, pearls or flakes and is valued as food for invalids and infants.
3. Cassava or Manioc is the name generally applied to the plant and tapioca to the starch prepared from its tubers. In India, both the plant and the starch extracted from its tubers are called tapioca.
4. Tapioca floor: It is prepared by grinding white chips and is used in confectioneries, biscuits and other processed foods.
5. Thippi: the fibrous waste obtained as a byproduct in the extraction of starch and sago from cassava tubers is called Thippi.
6. Chips: Plain dried chips prepared from peeled tubers by slicing and sun-drying.
7. Parboiled chips: Prepared by drying sliced previously immersed in boiling water for 10 minutes.
8. Sago Wafers: A thin pre-gelatinised value added product from cassava which is normally deep fried and eaten.
9. Barada chips: Dried cassava chips ground into small pieces for feeding to swines.