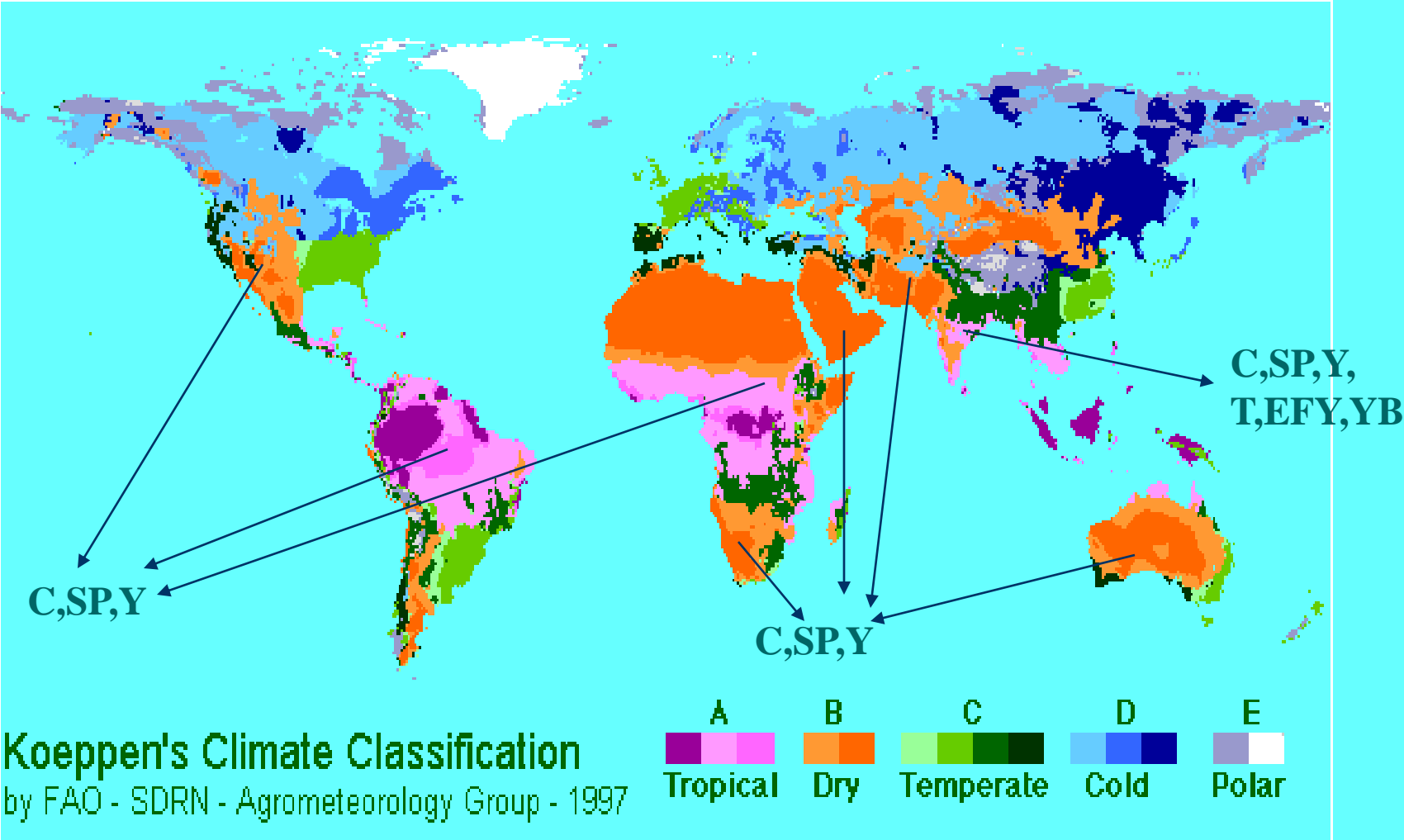


TROPICAL TUBER CROPS

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MSSSoA, CUTM

DIVERSITY OF TUBER CROPS IN HUMID TROPICS



Efficiency of food production of tuber crops

Important Food Crops

1. Wheat

2. Rice

3. Maize

4. **Potato**

5. Barley

6. **Cassava**

7. **Sweet potato**

(Ghosh *et. al.* 1988)

Carbohydrate production

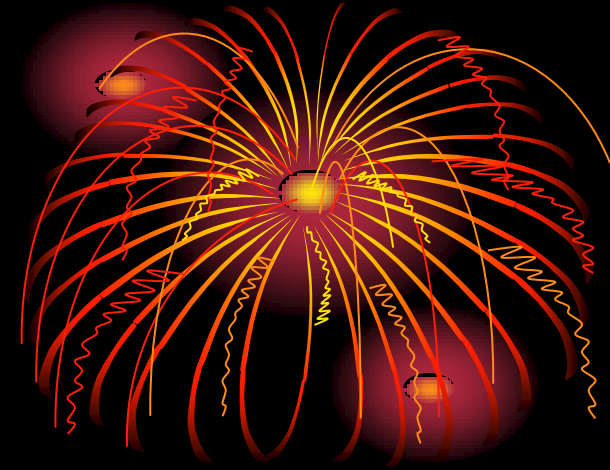
Tuber crops

- 6.7 t ha⁻¹

Rice or Wheat

- 0.8 t ha⁻¹

(Mandal, 1993)



Our vegetable requirement is 285-300 g/day

**Balanced diet for an adult man
should include 100g of root and
tubers**

Important tropical tuber crops

Common Name	Scientific Name	Family
Cassava	<i>Manihot esculenta</i> Crantz	Euphorbiaceae
Sweet potato	<i>Ipomoea batatas</i> (L.)Lam	Convolvulaceae
Greater yam	<i>Dioscorea alata</i> L.	Dioscoreaceae
White yam	<i>Dioscorea rotundata</i> (Poir)	Dioscoreaceae
Lesser yam	<i>Dioscorea esculenta</i> (Lour).Burk	Dioscoreaceae
Potato yam	<i>D.bulbifera</i> var. <i>sativa</i>	Dioscoreaceae

Taro	<i>Colocasia esculenta</i> (L.) Schott	Araceae
Tannia	<i>Xanthosoma sagittifolium</i>	Araceae
Elephant yam	<i>Amorphophallus paeoniifolius</i>	Araceae
Chinese potato	<i>Solenostemon rotundifolius</i>	Labiatae
Yam bean	<i>Pachyrrhizus erosus</i> (L)Urban	Leguminosae
Winged bean	<i>Psophocarpus tetragonolobus</i> DC.	Leguminosae

West arrow root	Indian	<i>Maranta arundinacea</i>	Marantaceae	koova
Queensland Arrow root or Purple arrowroot		<i>Canna edulis</i> Ker- Gawier	Cannaceae	
Alocasia		<i>Alocasia macrorhiza</i>	Araceae	

Importance

- # Grown in a wide range of soil and climate
- # Flexibility in planting and harvesting time
- # Propagation is much easier than other crops
- # Can be grown in less care and management practices
- # Less susceptible to insect-pests and diseases
- # Give more yield with less time per unit area.
- # Can be fitted well in multiple cropping systems
- # Immense industrial value
- # Nutritional/Therapeutic value

Negative consumption relationship with increase in per capita income- Poor man's crop

Nutritional Importance

- Major source of starch
- Excellent source of dietary fibre
- Rich in Vitamin A & C
- Rich in minerals

Cassava--50% more of wheat
Colocasia leaves - 80% more
minerals than cabbage

Proximate principles and calories of tuber crops

Crop	Grams per 100g on dry-weight basis					Calories
	Proteins	Fat	Minerals	Fibre	Other carbohydrates	
Potato	7.3	0.4	2.4	1.6	89.0	382
Sweet potato	3.8	0.9	3.1	2.5	88.5	377
Cassava	1.7	4.9	2.5	1.5	84.9	386
Yam	4.7	0.3	5.3	3.3	86.6	370
Colocasia	11.6	0.4	6.3	3.7	78.5	361
Elephant foot yam	5.6	0.5	3.8	3.8	86.3	371
Colocasia leaves (Black variety)	31.9	9.4	11.8	8.5	38.0	362
Colocasia leaves (Green variety)	22.6	8.7	12.8	16.8	39.4	325
Sweet potato leaves	21.8	4.2	11.4	12.5	50.4	328

Source: Gopalan *et al* 1971

Energy Yield

Crop	Cal. ha⁻¹day⁻¹
Cassava	250 x 10³
Sweetpotato	240 x 10³
Rice	176 x 10³
Wheat	110 x 10³
Maize	200 x 10³

Area and production

	World	India
Area	29.8 m ha	1.4 mt
Production	313.5 mt	22.1 mt

Two-third production is from developing countries

Adaptability of crops

Crop	Temp (°c)	Rainfall (cm)	ph	Light	Soil fertility
Cassava	25-29	100-150	5-6	Shade sensitive	low
Sweet potato	>24	75-100	5.6-6.6	Shade sensitive	low
Yams	25-30	115-150		Shade intolerant	High
Taro	21-27	150-250	5.5-6.5	Shade tolerant	high
Tannia	13-29	140-200	5.5-6.5	Shade loving	high

Important features of tuber crops

Crop	Planting time	Duration (Months)	Yield (q/b)	Income (Rs.000') /bigha
Cassava	May-June	8-9	30-40	5-6
Sweetpotato	Oct-Dec	3.5-4	30-40	5-6
	May-June	4-5	40-50	6-7
Yam	May-June	8-9	40-50	8-10
EFY	Feb-April	5-6	90-100	15-20
	May-June			
Taro	Feb-April	5-6	20-25	5-6
	May-June			
Swamp taro	Dec-Jan	7-8	35-40	7-8
Yam bean	Sep-Oct	3.5-4	85-50	7-8



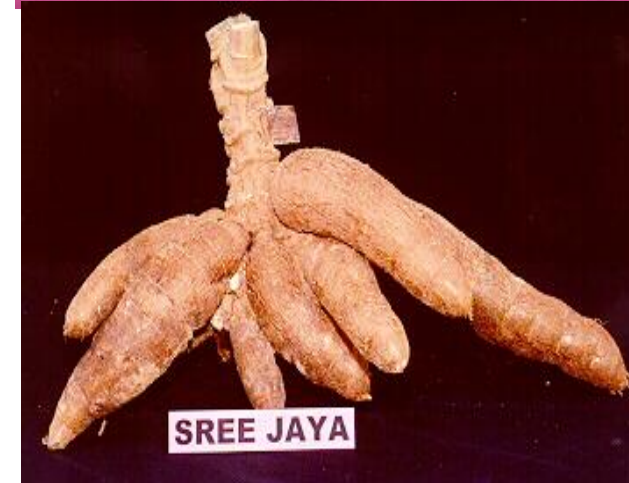
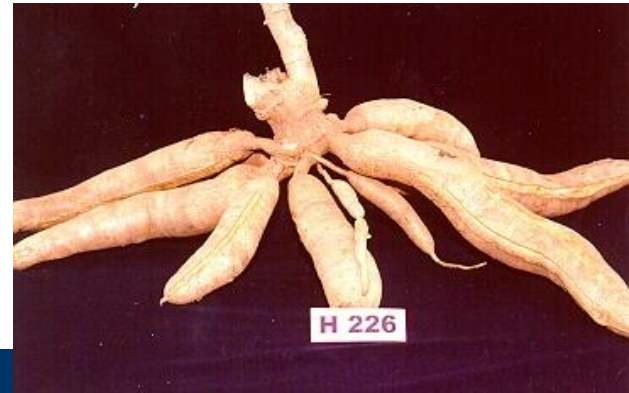
Cassava (*Manihot esculenta*)

Euphorbiaceae $2n=36$

- **Native to South America (N. E. Brazil)**
- **Starchy staple in tropics (Africa, S. America, Asia)**
- **Also called *manioc*, *yuca* and *tapioca***
- **Introduced to India - Portuguese**



CASSAVA





BRAZIL

Cassava

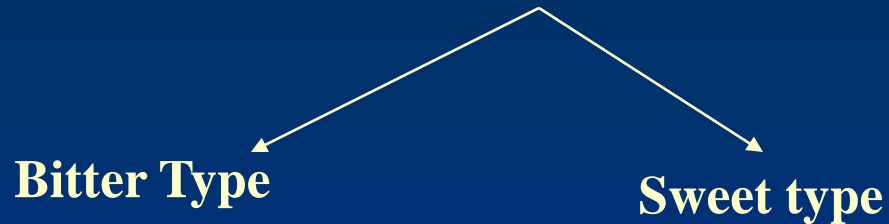


Area and production (cassava)

	Area (m.ha)	Production (mt)	Productivity (t ha ⁻¹)
World	16.37	164.75	10.2
India	0.24	6.06	24.5

- Africa - > 50% of world area & production of cassava
- Nigeria – Ranks first in the world in area (16.5 %) & production (18.5%)
- India – Ranks 12th in area , 7th in production But 1st in productivity in the world
- In India, Kerala leads in area & production of cassava.

Cassava varieties



- **fleshy roots contain poisonous compounds (cyanogenic glycosides - compounds that liberate cyanide) that must be removed before eating**
- **In sweet types this will be concentrated on the rind**
- **The usual method of cooking, chipping, drying, parboiling and drying reduce the glucocide content significantly**

H-97



- It is a high yielding variety of tapioca. Hybrid.
- Medium tall plants(1.5-2 m).
- Tubers with 27 - 29 percent starch;
- Yield of 25-35 T/Ha.
- **Duration 10 months.**
- Field tolerant to drought conditions as well as to Cassava Mosaic Disease (CMD) .

H -165



- It is a high yielding variety of tapioca.
- Hybrid.
- Medium tall (1.5 - 2 m).
- Starch content 23 - 25%.
- It is easily harvestable with good tuber shape.
- Duration 8-9 months.
- Yield 33- 38 T / Ha.
- Field tolerant to CMD.

Sree Visakham



- **It is a high yielding variety of tapioca.**
- **Hybrid.**
- **Non branching tall (2- 2.5 m).**
- **Carotene content 466 IU.**
- **Starch content in fresh tubers 25-27 %.**
Duration 10 months.
- **Yield 35-38 T/ Ha.**

Sree Sahya (H2304).



- It is a high yielding variety of tapioca.
- Multiple cross hybrid.
- Tall (2-2.5 m).
- Erect-branching.
- Occasional branching of tubers.
- Hardy and highly resistant to drought.
- Starch content 29-31 %.
- Yield 35-40 T/ Ha.
- Duration 10-11 months.

Sree Prakash

- It is a high yielding variety of tapioca.
- Selection from indigenous germplasm.
- Suitable for lowland cultivation.
- Short (1-1.5m) and non-branching.
- Duration 7 months.
- Yield 35-40 T / Ha.
- Starch content 29-31 % in fresh tubers.

Sree Harsha(H-2-14)

- **It is a high yielding variety of tapioca.**
- **Triploid Variety.**
- **High yield and dry matter.**
- **Suitable for industrial purposes.**
- **Erect non-branching.**
- **Recorded an yield of 35-40t/ha.**
- **Starch content 38-41%.**

H - 226

- **It is a high yielding variety of tapioca.**
- **Hybrid.**
- **Medium tall (2-2.5 m).**
- **Starch content 28 - 30 %.**
- **Most popular variety in industrial areas.**
- **Duration 10 months.**
- **Yield 30-35 T / Ha.**

Short duration varieties

Kalpaka

Non branching
Duration 6 months
Suitable for intercropping
in coconut in reclaimed
alluvial soils

Sree Vijaya

Duration 6 months.
Yield -25-28t/ha.
Starch content 27-30%.
The tuber flesh colour is
light yellow after
cooking.

Sree Jaya(CI-649)

High yielding variety of
tapioca.
Duration 6 months.
Tuber yield:26-30t/ha
24-27% starch.

Vellayani Hraswa

High yielding
Duration 5-6months
Very good cooking quality
Starch 27.8%
Cannot tolerate drought

Nidhi

High yielding
Duration 5.5-6 months
Tolerant to mosaic and
moisture stress
Starch content 26.8%

Vellayani Hraswa



Ambakadan

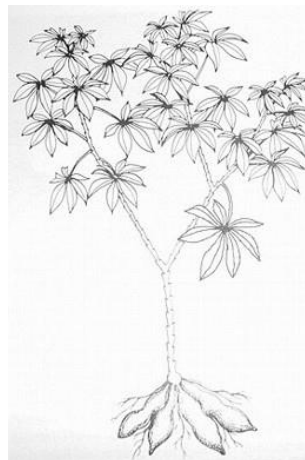


Adaptability

- **Cassava is cultivated from latitudes 30° N to S.**
- **Crop of lowland tropics.**
- **Up to an elevation of 2000m.**
- **Optimum temp is 25-29°C.**
- **Tolerate very hot climate.**
- **Growth reduced if temperature falls below 18-20°C.**
- **Cassava classified as sun loving crop.**
 - * **With shading there is drastic reduction in yield.**
 - * **The crop can withstand drought situations**
- **Tolerates acidity**

Varied Uses

- **Best substitute for cereals in animal feed**
- **Raw material for the production of starch, sago etc.**
- **Leaves, tuber rind and 'thippe' (waste from starch factory) used as animal feed**
- **30% starch, 1-3% protein**



- **58% of cassava is used as food**
- **28% as feed or feed ingredients**
- **4% in alcohol and starch industries**
- **10% is wasted**



Value added products of cassava

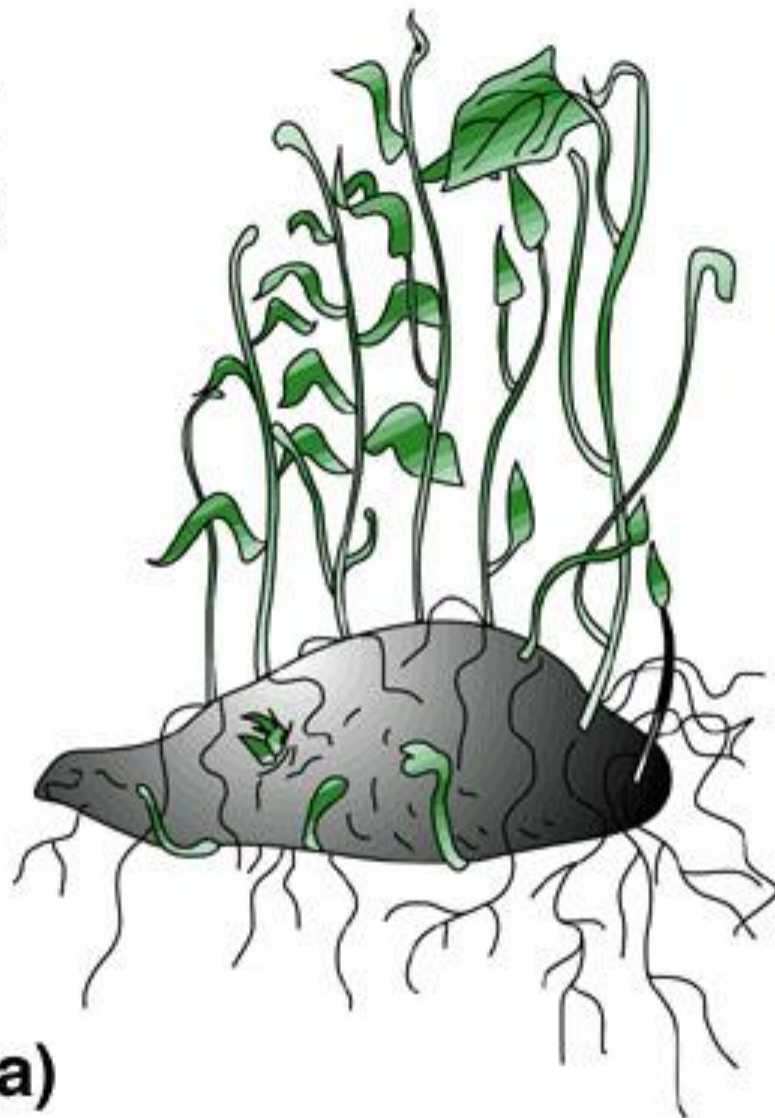
- ❖ **Starch- Textile, Adhesive, liquid glucose, confectionery, laundry, pharmaceuticals**
- ❖ **Sago - Human consumption, Textiles**
- ❖ **Wafers - Human consumption**
- ❖ **Chips - Human consumption**
- ❖ **Flour - Animal feed, sizing clothes, gum manufacturers**
- ❖ **Pappad - Human consumption**

Sweet potato

(Ipomoea batatas)

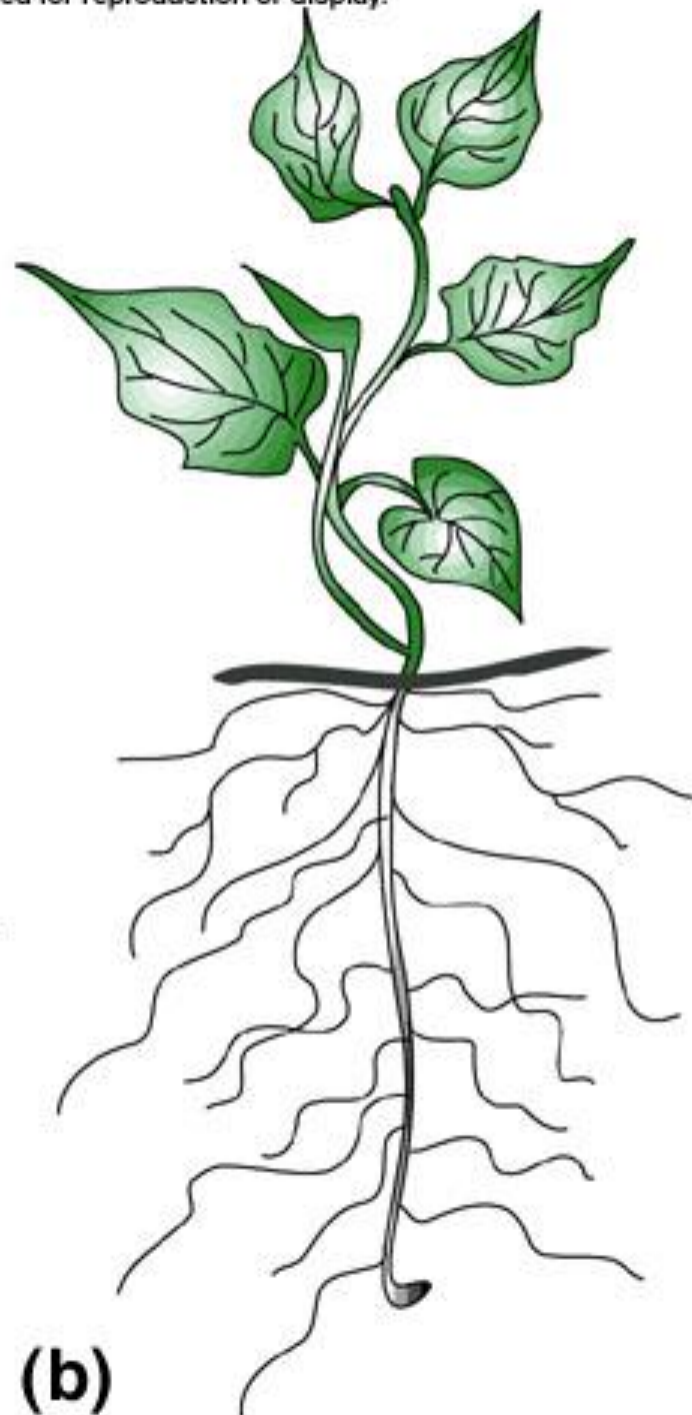


Sweet Potato



(a)

Produces tuberous roots



(b)

Sweet potato (*Ipomoea batatas* (L) Lam.)

Family: Convolvulaceae

- ❖ Warm-season crop
- ❖ Tropical perennial (from S. America)
- ❖ Grown by natives of South America as well as Malaysia and Polynesia.
- ❖ Used as evidence of pre-Columbian contact between Pacific Islanders and South Americans.
- ❖ Introduced to Europe (Spain) by Columbus

Important features

- ❖ Sweet taste
- ❖ Rich in CHO
- ❖ Rich in vitamin A (**β -carotene 0.5-40 mg/100g**) and C (**15-29 mg/100g**)
- ❖ 3-6% of carbohydrate is sugar
- ❖ Natural coloring agent
- ❖ Anti carcinogenic property

Adaptability

- **Grows best at temperature above 24⁰c.**
- **Temperature below 10⁰c, crop damaged by frost.**
- **Shade sensitive crop. It can tolerate 25 % shade.**
- **Requires 500mm rain fall.**
- **Tuber yield affected if drought occurs in the first 6WAP.**
- **Grows best on sandy loam soils. Clay soil not suited, produces pencil tubers.**
- **Soil pH of 5.6-6.6.**
- **Sensitive to alkaline and saline soils.**

- **Sweet potatoes grown year-round in the tropics.**
- **Shortest growing cycle of the root crops**
- **The crop is normally harvested in about 4 MAP**

Area and production

	Area (m.ha)	Prod. (mt.)	yield (t ha ⁻¹)
World	9.50	140.9	13.0
India	0.14	1.7	8.8

- ▶ **80 per cent of world production in China,**
- ▶ **U.S. accounts for 1 per cent of production**

Sweet potato

Two types

- Cream-to-light yellow colored flesh
- Yellow or deep orange colored flesh



VARIABILITY IN FLESH COLOUR



VARIABILITY IN SKIN COLOUR

Sree Nandini



It is a high yielding variety of sweet potato developed through Open pollinated seed progeny

Semi spreading variety

Early maturing (100-105 days).

Suitable for paddy fallows as a catch crop

Yield 20-25 t / ha.

Good starch content (18%)

Sree Vardhini

- It is a high yielding variety of sweet potato.
- Open pollinated seed progeny.
- Semi spreading variety.
- Early maturing (100-105 days)
- Dual purpose variety.
- Carotene content 1200 IU/100g.
- Yield 20-25 t / ha.



Other important varieties

Sree Bhadra , Samrat , Gouri , Shankar,

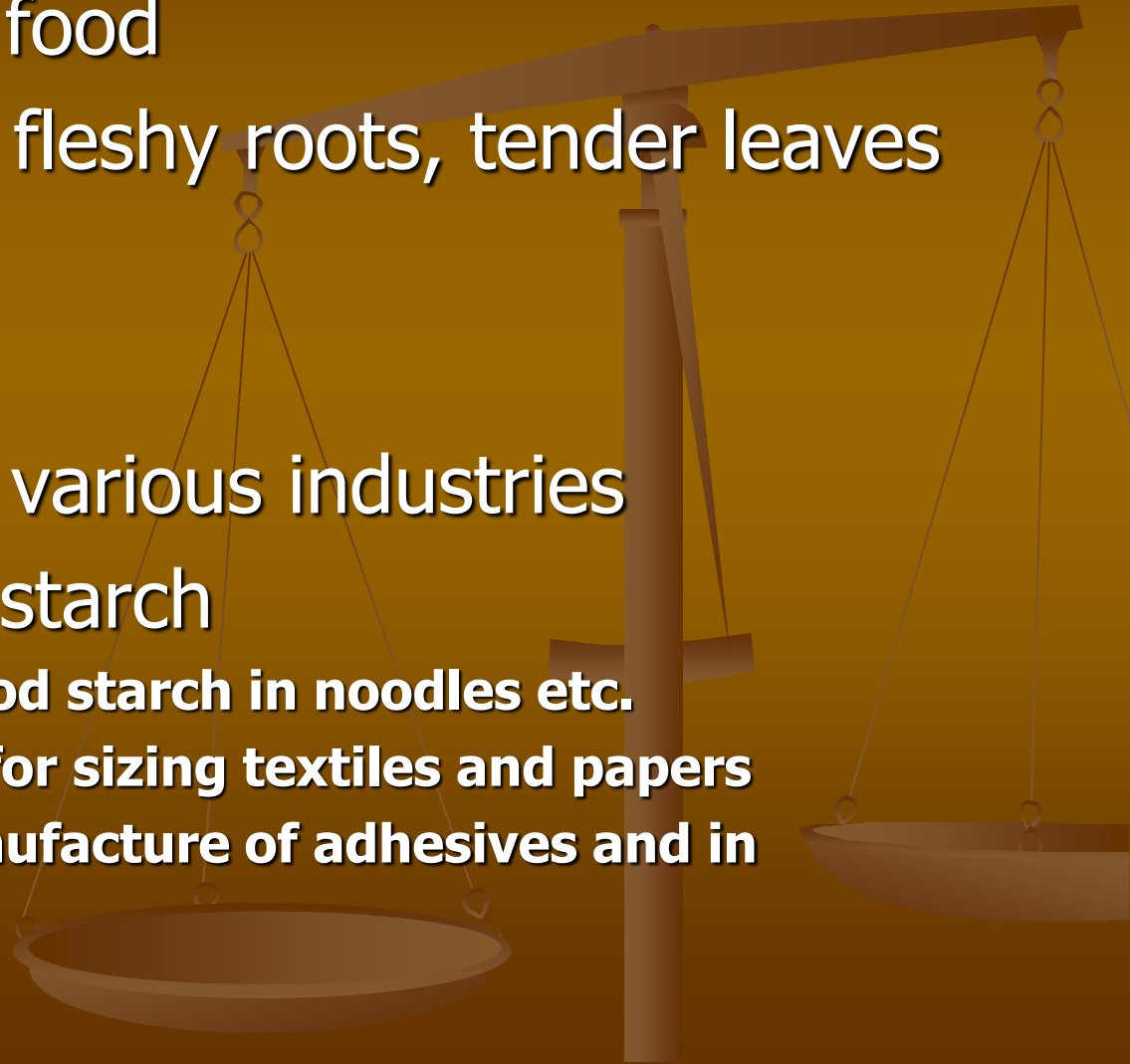
H-85/16, OP-21, Kamala Sundari, Bidhan

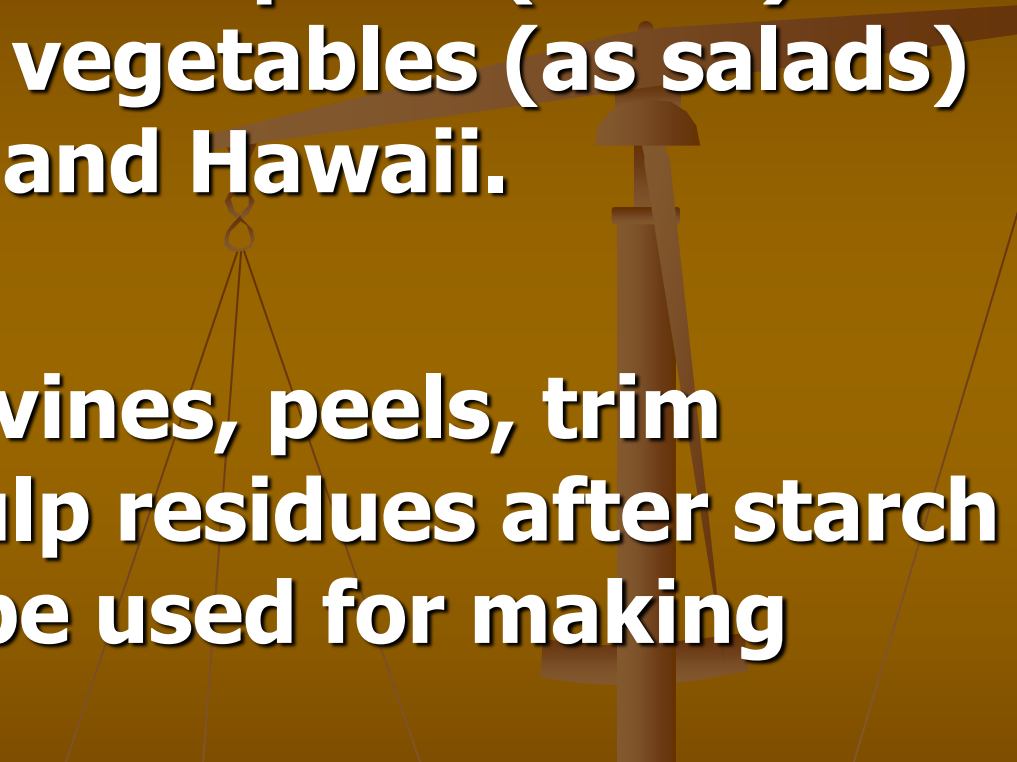
Jagannath , Kalmegh, R.S.-5, Pusa Safed,

Sree Arun, Sree Varun

Varied Uses

- Used as a staple food
- As a vegetable – fleshy roots, tender leaves
- Snack food
- Animal feed
- Raw material for various industries
- Yields important starch
 - used as a food starch in noodles etc.
 - Technically for sizing textiles and papers
 - For the manufacture of adhesives and in laundries.



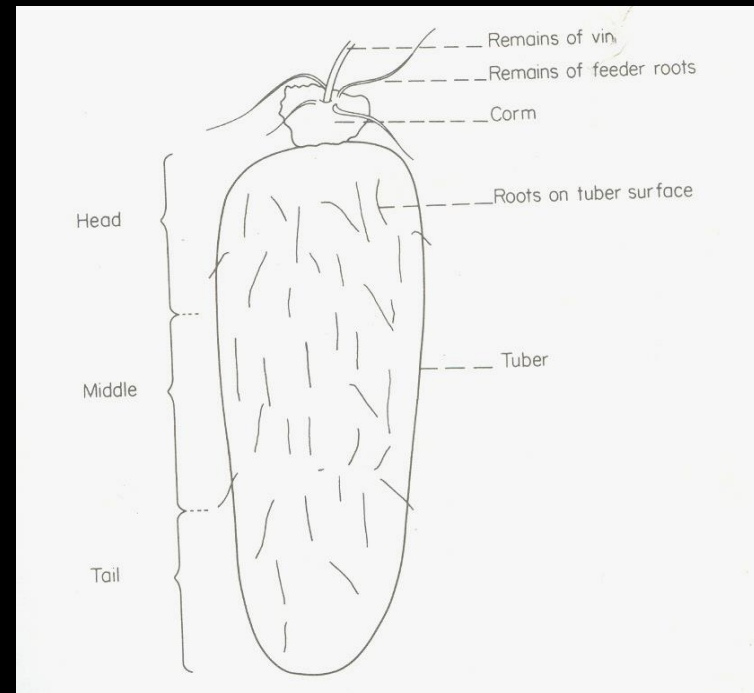
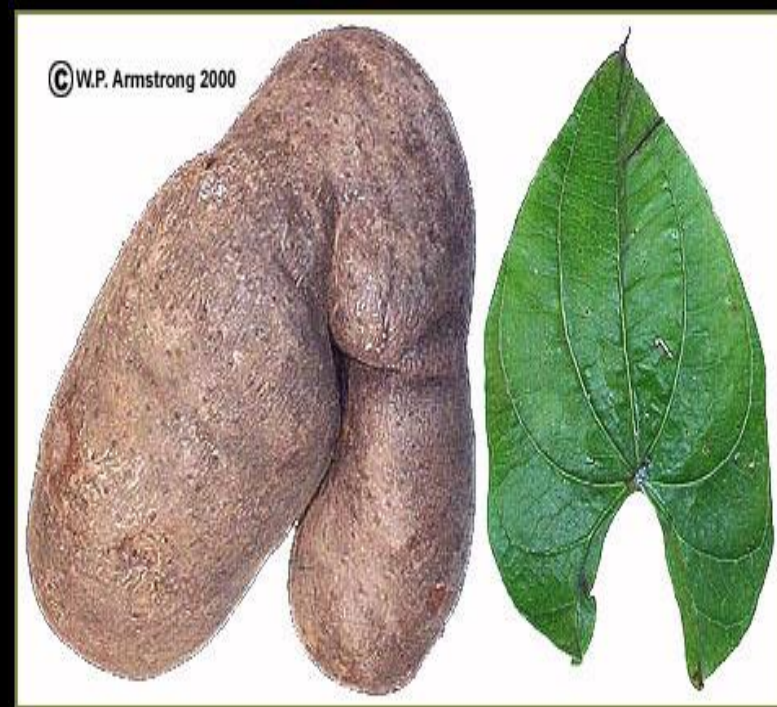
- 
- **The leafy top of the plant (vines) are used as green vegetables (as salads) in Asia, Africa and Hawaii.**
 - **Sweet potato vines, peels, trim wastes and pulp residues after starch recovery can be used for making silage.**

Yams (*Dioscorea sp.*)

- Family Dioscoreaceae
- Origin W. Africa
- Tubers large and hard to harvest
- Contains 20% starch
- Low in protein, vitamins (low in carotene too), & minerals
- Tubers contain *saponins*, type of steroid
Once used to make human sex hormones and cortisone

The genus *Dioscorea* contains a wide range of species (more than 500). Out of which 50 species are found in India.

The edible yams comprise mainly three species

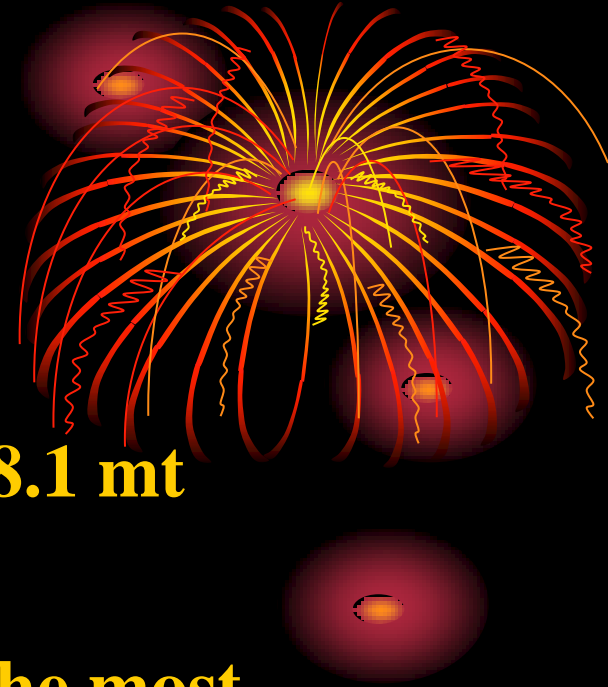


YAMS

GREATER YAM	<i>Dioscorea alata</i> (L.)	<i>Dioscoreaceae</i>
AFRICAN YAM	<i>Dioscorea rotundata</i> (Poir.)	<i>Dioscoreaceae</i>
LESSER YAM	<i>Dioscorea esculenta</i> (Lour.)Burk.	<i>Dioscoreaceae</i>

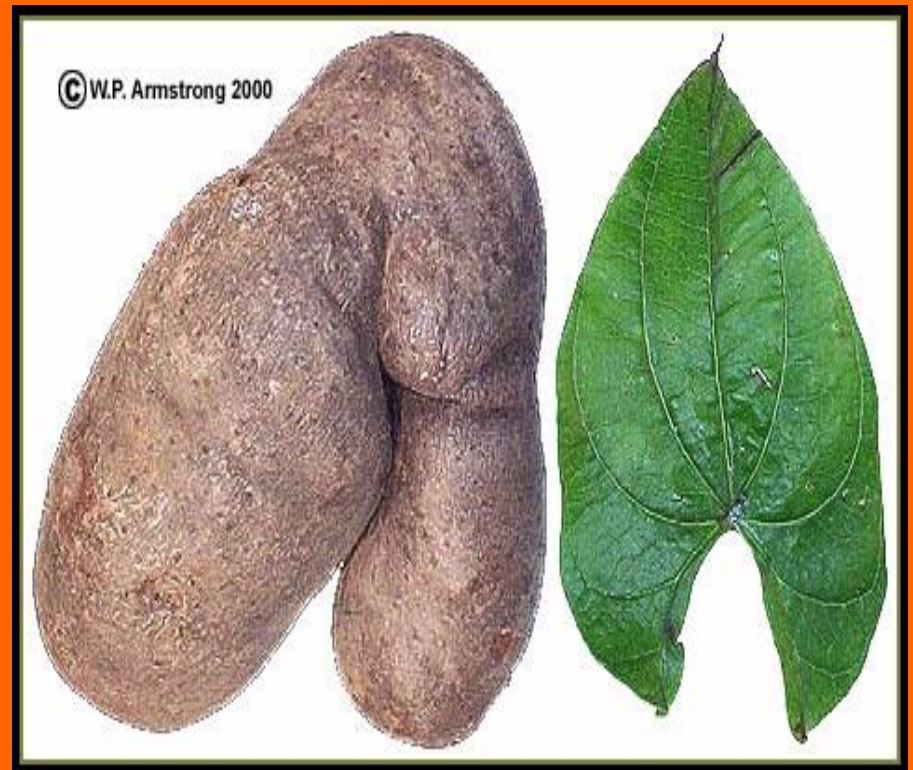
Yams

- **The world production of yam -- 28.1 mt**
- **96% came from West Africa**
- **In West Africa, yams are one of the most highly regarded food products**
- **They are closely integrated into the social, cultural, economic and religious aspects of life. Traditional ceremonies still accompany yam production, indicating the high status given to the plant.**



Greater yam (*Dioscorea alata* L.)

- Originates from South East Asia
- The species most widely spread throughout the world
- Tuber shape is generally cylindrical, but can be extremely variable.
- Tuber flesh is white and "watery" in texture.



Varieties of Greater Yam

■ Sree Keerthi

Climb to a height of 4-5m

Starch content 20-22 %

Good cooking quality

Excellent taste.

Duration 9-10 months.

Yield 25-30 T / Ha.

■ Sree Roopa

Climb to a height of 4-5 m

Tubers are smooth

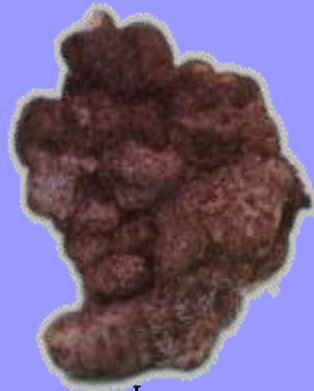
Excellent cooking quality.

Starch content 17-19 %

Protein 1-2 %.

Duration 9-10 months.

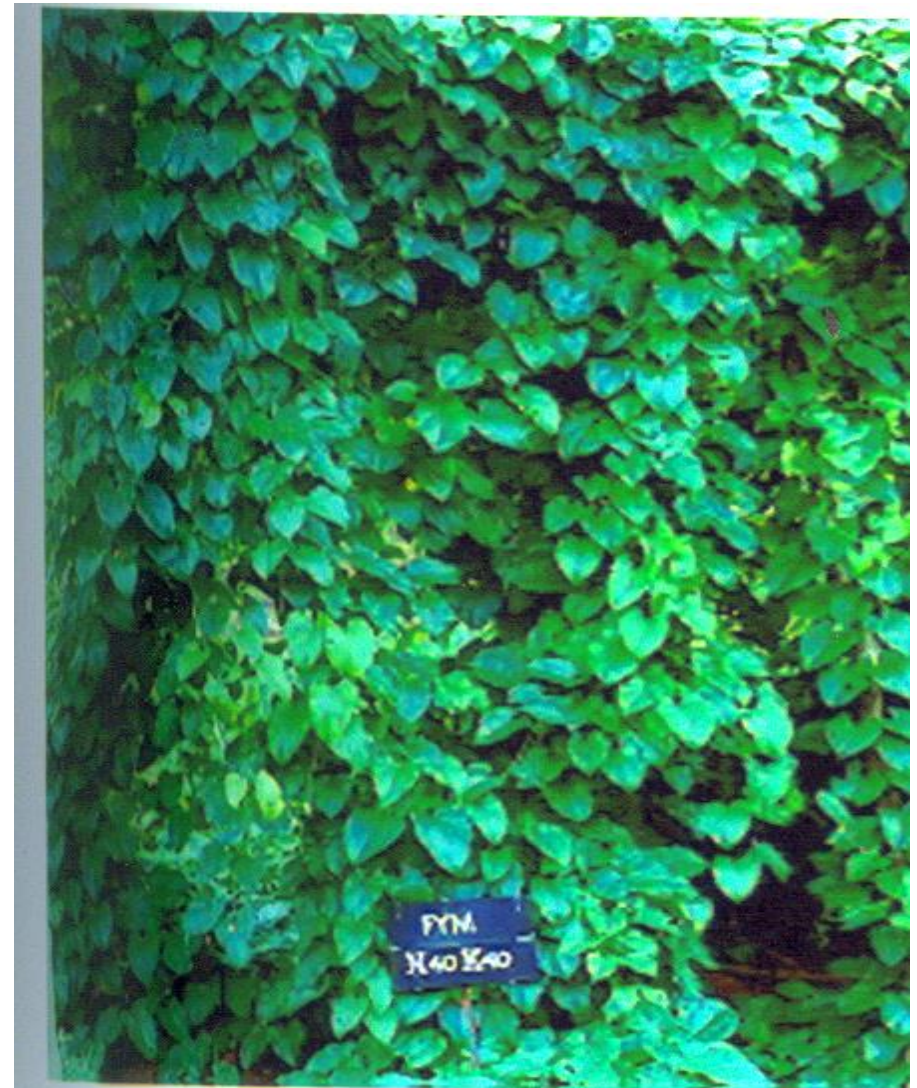
Yield 25-30 T / Ha.



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White or African yam (*Dioscorea rotundata* Poir)

- Originated in Africa
- The most widely grown and preferred yam species
- The tuber is roughly cylindrical in shape, the skin is smooth
- The flesh usually white and firm





White yam



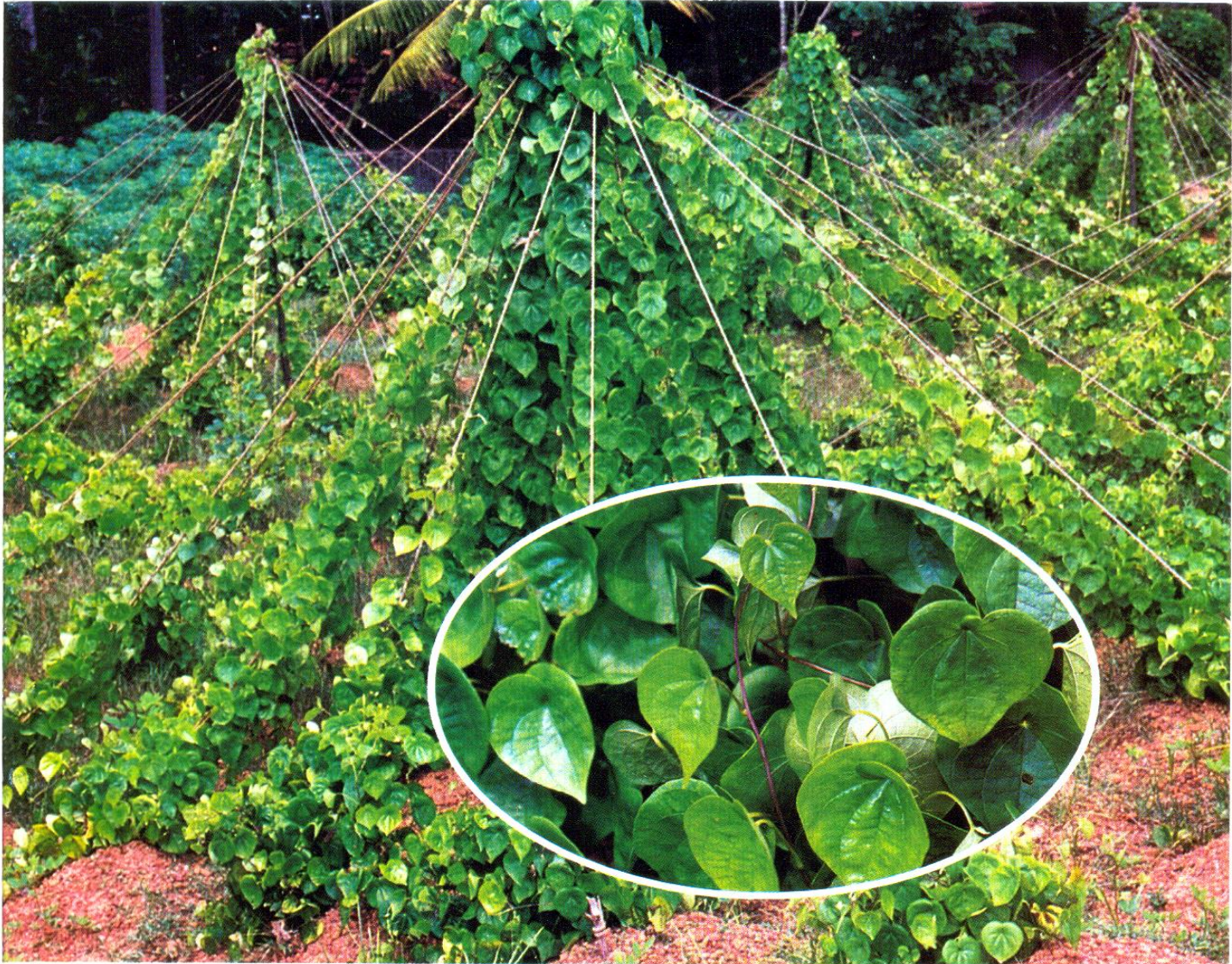
As intercrop in coconut

Varieties

Sree Priya,
Sree Subhra



LESSER YAM



Sree Latha

LESSER YAM VARIETIES

Sree Kala



Duration 7.5- 8 months.

Yield 25 t/ ha.

Starch content 24.4 %

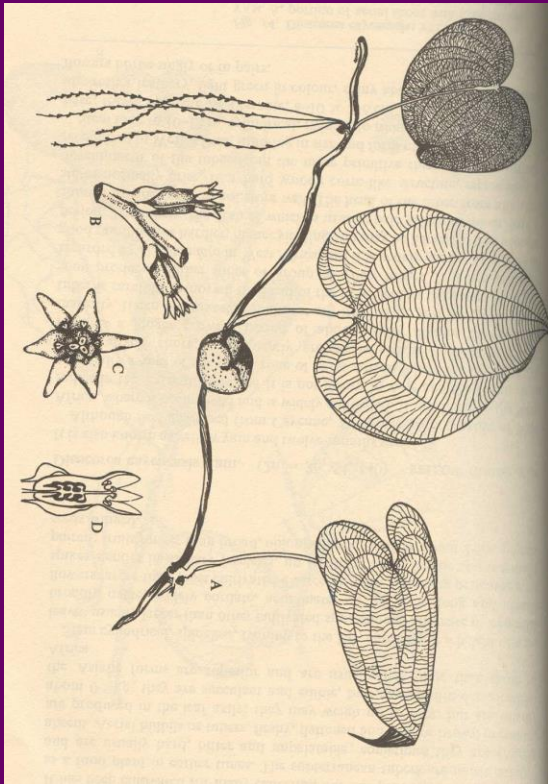
Tubers oval in shape

Excellent cooking quality

Yield 20-25 t/ha

**Tuber surface very
smooth and hairs absent**

D. bulbifera



- ❖ **Major Alkaloid is Diosgenin-used as contraceptive pills**
- ❖ ***D. floribanda*, *D. prazeri* are the two important species, Diosgenin is commercially extracted.**

AROIDS

TARO	<i>Colocasia esculenta</i> (L.) Schott	Araceae
TANNIA	<i>Xanthosoma sagittifolium</i>	Araceae
ELEPHANT FOOT YAM	<i>Amorphophallus paeoniifolius</i> (Dennst.) Nicolson	Araceae

Classification of taro

```
graph TD; A[Classification of taro] --> B[Upland taro]; A --> C[Lowland taro]; B --> D[Eddoe]; B --> E[Dasheen]; C --> F[Swamp taro]; C --> G[Giant Swamp taro];
```

Upland taro

Lowland taro

Eddoe

Dasheen

Swamp taro

Giant Swamp taro

cocoyam

- ▶ *Colocasia esculenta* (taro) → old cocoyam
- ▶ *Xanthosoma* sp. (tannia) → new cocoyam

cocoyam

- “potato of the humid tropics”
- *Poi*, traditional dish of native Hawaiians
- Corms are steamed, crushed, made into a dough, and fermented
- Cooked similar to potatoes
- Processed into flour, chips, breakfast foods



Old cocoyam

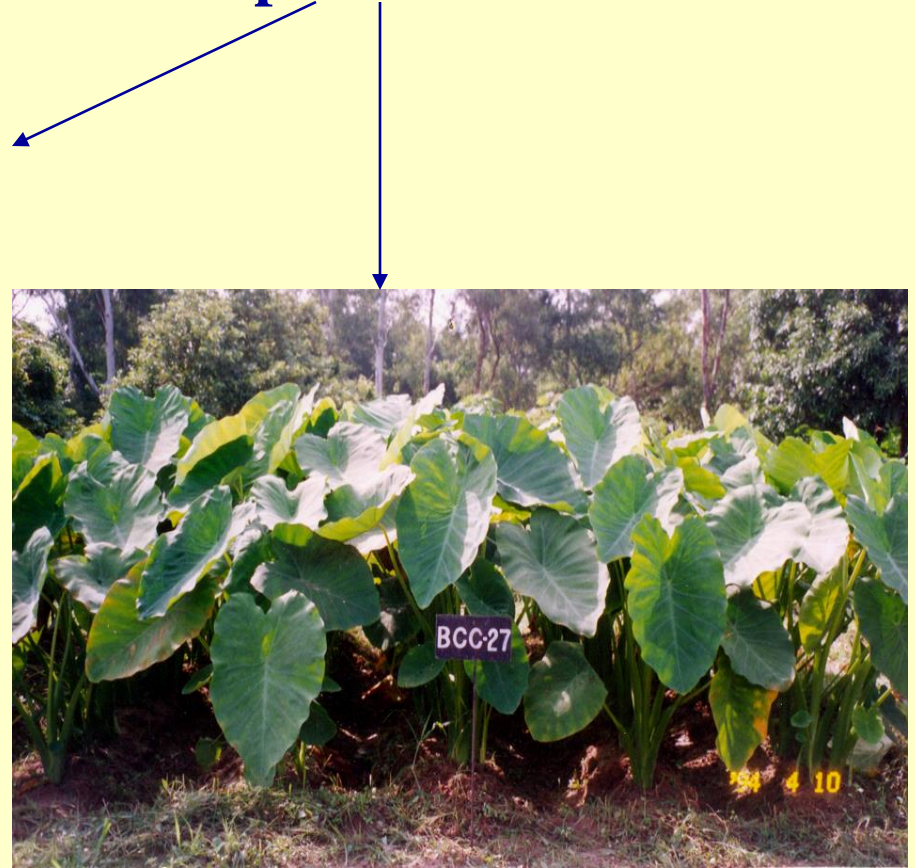


New cocoyam



Colocasia esculenta var
esculenta(dasheen type)

Upland taro



Colocasia esculenta var.
antiquorum (eddoe type)

Varieties of eddoe taro

Bidhan Chaitanya

Bidhan Joydeb

Sree Reshmi

Sree Pallavi



BIDHAN CHAITANYA

BIDHAN JOYDEB

These two varieties are early maturing (5-6 months), tolerant to *Phytophthora* blight and give yield to the tune of 15-20 t/ha.

Dasheen type mother corm



EAC-3

C. esculenta
(Banda type)



Swamp taro (*C.esculenta* var. *stolonifera*)

Lowland taro



Giant swamp taro
(*Cyrtosperma chamissonis*)

TANNIA



Giant taro



ELEPHANT FOOT YAM

(*Amorphophallus paeoniifolius*)

- Two distinct forms
 - Forma *sylvestris*
scabrous petiole
more acrid
 - Forma *hortensis*
smooth petiole
acridity less



uses

- As vegetable
- Boiled and baked product
- Source of starch
- Medicinal property
- Flour has got varied uses



Varieties: Bidhan Kusum, Gajendra, Sree Padma

Vegetable production

- ❖ Corm weighing about 500g is economically beneficial for planting.
- ❖ Generally planted at a spacing of 75 cm in both ways during February to March.
- ❖ Fertilized with 150 kg N, 120 kg P₂O₅ & 150 kg K₂O along with 20-25 t FYM/ha.
- ❖ Harvested within 5-6 months after planting.
- ❖ Yield: 80-100 t/ha.

Seed production

- ❖ 100-150 g mini corm sett is ideal.
- ❖ Planted at a spacing of 50 cm in both ways.
- ❖ Fertilized with 100: 75: 100 Kg NPK/ha.
- ❖ Harvested within 8-9 months after planting.

Seed production through mini corm sets



Minor Tuber Crops

- Chinese potato *Solenostemon rotundifolius*
- Yam bean *Pachyrhizus erosus*
- Winged bean *Psophocarpus tetragonolobus*
- West Indian
arrow root *Maranta arundinacea*
- Queensland
arrow root/
Purple arrow root *Canna edulis*

Yam bean



It is a leguminous sexually propagated tuber crop

Raw tuber is used as juicy fruit

Seed contains rotenone which acts as botanical insecticide

Released variety- RM-1

West Indian Arrow root

- Arrowroot introduced to Europe by European settlers of the New World from the Arawak / Caribbean Islands & regions north of Brazil.
- The Arawak named it *aru-aru*, meaning "meal of meals".
- The Arawak used arrowroot tubers to draw poison from wounds inflicted by poisoned arrows, hence the name "arrowroot".



Arrow root

- **Shade loving crop**
- **Arrowroot starch easily digestible**
- **Base for tablets**
- **Food for infants and invalids**
- **Health drink**
- **Possess demulcent properties**



COLEUS

Chinese potato (Coleus) grown in most of the homestead gardens.

The plant is a small herbaceous bushy annual with succulent stems and aromatic leaves.

The crop duration is 5 months.

The plant bears a cluster of dark brownish tubers



Queensland arrow root

- Grown throughout the country for edible rhizomes.
- The fleshy rhizomes flavour and taste with less fibre.
- Young rhizomes used as vegetable. It contains 20-25% starch.
- The starch is easily digestible
- The bakery products from canna starch are much lighter, spongier and crisper than those from wheat products.



Tuber

Intercropping System



Cassava + cowpea

Cassava + groundnut

Homesteads

- Tuber crops are major component of most of the homesteads

Tuber crops and trade

- Enhance market appeal through value addition
- Broadening the spectrum of utilization

Tuber utilization

As food

- Boiled/baked candies
 - Fried pickles
 - Fermented jam
 - Sago sauce
 - Bread cutlet
 - Rave puffs
- gulabjamuns etc.

Cassava is marketed in three ways

- As raw materials to industries
- As value added products
(starch,sago,chips)
- As by product of starch/sugar industries (Thippi & peel)

As Value added Product

- Starch & Sago – Co-operative marketing system (SAGOSERVE)
 - Flour – Direct marketing
 - Wafers – co-operative marketing (WAFERSERVE)
- 

Starch

Vast potential in food and industry

- Easily digestible food
- Biodegradable plastic
- Sweeteners
- Alcohol
- Textile and paper industry
- Starch derived products **dextrins, glucose syrup, fructose syrup, sago**

Value added products

**Different types of
cassava products,
cassava bread
and cassava starch**



**Value added products
eddoe chips and sweet
potato chips**





Cassava chips



Sweet potato French fries



Sweet potato Golab Jamun



Sweetpotato Jam



Sweetpotato Pickles



Sweetpotato squash



Amorphophallus Payasam

Anti-nutritional factors

Potentially toxic / reduce the bioavailability of other nutrients

(i) Cyanide in Cassava

(ii) Flatulence and Trypsin inhibitors in Sweet potato

(iii) Acridity of Aroids

Cyanide toxicity in humans

- Cyanide –normal constituent of blood
- Blood concentration of cyanide is <12 $\mu\text{mol} / \text{l}$.
- Lethal action of cyanide \rightarrow blocking the reduction of O_2 in respiratory pathway.

Cyanide concentration

10-1000mg per kg of fresh tuber

Concentration, mg kg⁻¹

Toxicity

<50

- harmless

50-80

- slightly poisonous

80-100

- toxic

>100

- fatal

Acridity of aroids

- ★ Forceful ejection of raphides or needle like crystals (insoluble calcium oxalate) from the idioblast causes irritation.
- ★ Proteolytic enzymes –role in irritating reactions and proteinases occur in corms

Removal of acidity

- **Selection/breeding acid free varieties**
- **Treatment with acids like hydrochloric acid, tartaric acid and citric acid.**
- **Cooking tubers in water or steam cooking**

Conclusion

Higher biological efficiency and higher rate of dry matter production per day per unit area make tuber crops inevitable and important components in our food security systems.



THANK YOU