ELEPHANT FOOT YAM

भाकृअनुप-केन्द्रीय कंद फसल अनुसंधान संस्थान
(भारतीय कृषि अनुसंधान परिषद्)
श्रीकार्यम, तिरुवनंतपुरम 695 017, केरल, भारत

ICAR-CENTRAL TUBER CROPS RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
Sreekariyam, Thiruvananthapuram 695 017, Kerala, India

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ICAR-Central Tuber Crops Research Institute
Sreekariyam, Thiruvananthapuram 695 017
Kerala, India
Tel.No. : (91) (471) 2598551 to 2598554
E-mail: director.ctcri@icar.gov.in
Website: https://www.ctcri.org

Published by
Dr. G. Byju
Director

Chief Editor
Dr. M. L. Jeeva

Editors
Dr. K. Sunilkumar
Dr. A. Asha Devi
Dr. H. Kesava Kumar
Dr. T. Krishnakumar
Dr. P. Prakash

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Akshara Offset, Thiruvananthapuram, Kerala.
Ph : 0471-2471174, email : aksharaoffset@gmail.com

Contents

ICAR-Central Tuber Crops Research Institute
Sreekariyam 695 017, Thiruvananthapuram, Kerala, India

Dr. G. Byju
Director

Phone: 0471-2598431
Email: director.ctcri@icar.gov.in

From the Director

Elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson, is mainly grown for edible purpose in Andhra Pradesh, West Bengal, Gujarat, Kerala, Tamil Nadu, Maharashtra, Uttar Pradesh and Jharkhand in India. It is cultivated in an area of 42,000 ha with a production of 10.40 lakh tonnes and productivity of 24.76 t ha^{-1}. The crop has high yielding potential per unit area than most of the other vegetables and is highly profitable and remunerative crop for the farmers of India. It is gaining popularity due to its shade tolerance, easiness in cultivation, high productivity, less incidence of pests and diseases, steady demand and reasonably good price due to nutritional and health benefits. The crop generates an employment to the tune of 410 man days per ha and the estimated market value of the crop is ₹ 26,000 million in our country.

The ICAR-CTCRI celebrates its Diamond Jubilee during 2023 and assumes significant role in the R&D of tropical tuber crops including elephant foot yam in India. The salient achievements of Institute for the growth and development of elephant foot yam sector are development of high yielding varieties, protocols for production of quality planting materials, agro techniques, cropping/farming system models, organic farming packages, water management, site specific nutrient management, diagnosis and integrated management of pests and diseases, storage techniques, value addition etc. Research and development of elephant foot yam is being intensified through partnerships and collaborations with SAUs, AICRP TC centres, KVKs, Department of Horticulture, FPOs and other stakeholders. It is my privilege to present the technical bulletin titled 'elephant foot yam' which covers the above package of practices to be utilized by the clients for maximizing the productivity and profitability from farming.

I hope that this technical bulletin will be a valuable reference document for the researchers, academicians, extension professionals, seed entrepreneurs, farmers, SHGs and other stakeholders. I appreciate the efforts of editorial team for publishing this important publication on time.

G. Byju

21 November 2023

Elephant foot yam

Scientific Name: *Amorphophallus paeoniifolius* (Dennst.) Nicolson

Introduction

Elephant foot yam (EFY) (*Amorphophallus paeoniifolius*) belongs to the family Araceae and is also known as the white spot giant arum. It is notable for its large and edible underground corm, which serves as a significant food source in many tropical and subtropical regions. It is, locally also known as "Suran" or "Jimmikand" in Hindi, "Chena" in Malayalam and "Chenai" in Tamil, is considered highly nutritious and offers the best substitute for meat. The plant blooms every year around the start of the rainy season. Basically a crop of southeastern Asian origin, it serves as a source of protein as well as starch. It has long been used as a local staple food in many countries such as the Philippines, Indonesia, Malaysia, Bangladesh, India, China and south eastern Asian countries. It is commercially cultivated due to its production potential and popularity as a vegetable in various Indian cuisines. In India, it is cultivated in states of Andhra Pradesh, West Bengal, Gujarat, Kerala, Tamil Nadu, Maharashtra, Uttar Pradesh, and Jharkhand. In the northern and eastern states, the wild, local cultivars grown are generally used for making vegetable pickles and medicine preparations for various ailments. The crop is also cultivated as an intercrop along with turmeric and under coconut or banana. The key botanical characteristics of the plant is given below.

Corm: The most recognizable part of the plant is its corm, which is the swollen underground stem used for food. The corm can be quite large and heavy, resembling an "elephant foot," which is how the plant gets its common name. It has a rough, textured surface with a light brown to reddish-brown color.

Leaf: The plant produces a single, large compound leaf that emerges directly from the tuber. The leaf is made up of several leaflets arranged in a pinnate pattern which are generally large, lobed, and have a distinct appearance.

Inflorescence: The inflorescence is unique and unusual. It consists of a tall, upright stalk called a spadix, which is covered by a large, leaf-like structure known as a spathe. The spathe is usually greenish-white or pale yellow with white spots on outside and dark brown to maroon inside, and it envelops the spadix. The inflorescence emits a strong and often unpleasant odor, which helps to attract pollinators, and fades after flowers are pollinated.

Flowers: The actual flowers are located on the spadix. The lower part of the spadix contains female flowers, while the upper part bears male flowers. The flowers are small and not particularly showy.

Fruits: Fruits are cylindrical berries which are green initially and turns bright yellow to orange to red.

Elephant foot yam plant

Elephant foot yam corms

Importance

This plant has a remarkable dry matter production capability per unit area, surpassing many other vegetables. In India, it stands out as one of the most economically profitable tuber crops. Furthermore, it offers a plethora of nutritional and health benefits. It's corms, when thoroughly cooked, serve as a versatile vegetable and it serves as a base for a variety of dishes, including curries, chutneys, kebabs, pickles, and sweet treats. They are also used to make chips. The tender stems and leaves find use as vegetables.

In the realm of traditional medicine, ayurvedic practitioners highly recommend EFY for maintaining regular bowel movements, particularly in cases of constipation. Its role in improving digestion and its use as a natural laxative are well-documented in folk medicine. This remarkable plant is a rich source of essential trace elements such as potassium, magnesium, selenium, zinc, phosphorus and calcium. It possesses anti-inflammatory properties and functions as a detoxifier. Notably, it has a positive impact on the condition of enlarged prostate glands and is employed as a carminative, offering effective anthelmintic properties. EFY stands as a unique and culturally significant plant that holds importance in both culinary and traditional medicinal practices. A detailed overview of its key characteristics is provided in Table 1.

Table 1. Characteristics of elephant foot yam

Parameters	Characteristics
Planting material (propagule)	Corms and cormels
Growth period (months)	8 to 9
Optimal rainfall (mm)	1000-1500
Optimal temperature (°C)	25-30
Drought resistance	No
Water logging tolerance	No
Shade tolerance	Yes

Nutrient requirements (kg/ha)	100:50:150
Seasonality of crop cycle	Yes
In-ground storage life	Good
Post-harvest storage life	Good
Leaves used for animal feed	No

Nutritional profile

An overview of the nutritional composition of EFY, including the corm, stem, and leaf is given in Table 2. The corms contain approximately 17 to 20% starch and have an exceptionally low sugar content of only 0.14%. In terms of protein content, the values range from 4.19 to 4.50%. Moreover, they possess calcium, iron, potassium, magnesium, copper, zinc, and manganese levels that are comparable to those found in many legumes. Remarkably, the leaves are rich in protein, with levels ranging from 20 to 22%.

Table 2. Nutritional profile of elephant foot yam corm, stem and leaf

Particulars	Elephant foot yam		
	Corm	Stem	Leaf
Proximate composition (FW)			
Moisture (%)	71.12-73.80	77.11-78.84	69.03-71.69
Energy (kJ/100 g)	324-374	-	-
Crude protein (%)	4.19-4.50	12.38-14.13	19.63-22.31
Starch (%)	17.30-20.10	-	-
Sugar (%)	0.14	-	-
Polyphenol (%)	1.25-1.84	1.16-2.47	1.25-1.84
Dietary fibre (%)	1.45	-	-
Crude fibre (%)	1.29-1.41	1.14-1.22	1.07-1.26
Crude lipid (%)	0.05-0.07	0.04-0.05	0.06-0.06
Ash (%)	1.82-1.85	1.86-1.89	1.82-1.85
Nutrient & Minerals (DW)			
N (%)	0.67-0.72	1.98-2.26	3.14-3.57
P (%)	0.20-0.03	0.54-0.74	0.35-0.46
K (%)	0.95-1.15	1.03-1.24	1.53-1.81
Ca (ppm)	920.00-992.00	2635.50-2995.00	1567.00-3240.00
Mg (ppm)	869.00-895.00	4325.00-5960.00	4032.00-5385.00
Fe (ppm)	56.80-59.20	102.80-970.20	178.40-250.20
Mn (ppm)	18.50-33.60	25.40-128.20	145.20-176.20
Zn (ppm)	38.20-51.60	96.20-136.40	130.60-300.40

Cu (ppm)	1.40-1.90	17.20-27.10	12.0-16.40
B (ppm)	1.42-1.71	-	-
Al (ppm)	0.41	-	-
Na (ppm)	4.01-5.80	-	-
Vitamins (mg/100g) (FW)			
Vitamin A	0-0.15	-	-
Thiamine	0.05-0.06	-	-
Riboflavin	0.02-0.07	-	-
Nicotinic acid	0.70-1.70	-	-
Vitamin C	1.50-6.00	-	-

Varieties

Sree Padma

Year of release	:	1998
Pedigree	:	A selection from indigenous germplasm collection from Wyanad (Kerala)
Yield	:	42.0 t ha^{-1}
Duration	:	8-9 months
Suitable growing region	:	Kerala
Key traits	:	Medium tall (78.0 cm); medium canopy spread (123.0 cm diameter); light green petiole with green ornamentations; petiole girth 13.0 cm; corm shape globose; brown tuber skin colour; cream tuber flesh colour; very good cooking quality; field tolerant to collar rot (*Sclerotium rolfsii*) and mosaic disease (virus); first variety from Kerala.

Sree Athira

Year of release	:	2006
Pedigree	:	Hybrid selection from the cross Am-15 x Am-45
Yield	:	39.7 t ha^{-1}
Duration	:	9-10 months
Suitable growing region	:	Kerala
Key traits	:	Medium tall (85-110 cm); medium canopy spread (105-120 cm); light green petiole with green ornamentations; petiole girth 13-15.5 cm; corm shape globose; tuber skin colour brown; tuber flesh colour light yellow; excellent cooking quality; tolerant to collar rot (*Sclerotium rolfsii*) and mosaic disease; first genetically improved variety released in this crop.

Climate and soil

EFY is a tropical/subtropical crop and hence thrives well under warm humid climate with a mean annual temperature of 30-35°C and a well distributed rainfall of 1000-1500 mm spread over a period of 6-8 months. The crop performs well under irrigated condition and hence could be grown in areas where the rainfall is scanty but has assured irrigation facility. Well distributed rainfall or ample moisture availability during the growth phase of the crop is essential as it promotes proper vegetative development of the crop. However, dry conditions towards the latter phase of its growth helps in the development and bulking of corm.

It grows well on a variety of soils, but a well-drained sandy loam or sandy clay loam soil with a near neutral soil reaction (pH 6-7) is ideally suited for the crop. The soil should be rich in organic matter with adequate amount of available nutrients.

Quality planting material production

Quality seed/planting material is the most important input in EFY as in any farming practice, as it affects the production, productivity and hence profitability of the crop.

Major features of EFY seed material are as follows:

- Bulkiness and perishability of seed material makes its handling, storage and transportation costly.
- The rate of multiplication is the lowest among tropical tuber crops (1:4).
- It has a long crop cycle (about 9 months) and dormancy period of about 2 months.

- Since seed material and edible part are the same, there is competition between ware corm and seed corm. As a result, often quality and quantity of next crop is affected.

All these contribute to shortage of quality seed/planting material in elephant foot yam.

Conventional method

Whole corms of 500 g size or cut pieces of corms (setts) of size 750 g each having a portion of terminal bud is the recommended planting material. Size of the planting material used influence mean corm girth, corm weight and corm yield. Before planting, the seed corm is dipped in cow dung slurry enriched with *Trichoderma harzianum* @ 5g/kg of seed material and shade dried for better sprouting and establishment. Mulching with green or dry leaves is recommended after planting and application of basal fertilizer dose for retaining the moisture content and regulation of soil temperature.

Minisett technique

The rate of multiplication is very low in EFY and based on the size, one to four planting material could be obtained per plant. Hence, minisett method was developed to increase the multiplication of seed corms. While in conventional method 750 g size setts are

Corm for minisett preparation

Minisetts with central eye

Minisetts ready for planting

Cut pieces ready for planting

Mulching after planting

Plant development from minisett

Protocol for preparation of elephant foot yam minisett

used for planting, in minisett method 100 g size sett is used. A study at ICAR-CTCRI showed that a sett weight of 100 g produced seed corms of 417 g mean weight, which was significantly superior to those of lower sett weights.

Since, the buds are located as a ring around the central bud, care must be taken while preparing minisett to ensure that each sett has a portion of this ring, without which it will not sprout. The setts are dipped in cowdung slurry and shade dried before planting. It is recommended to plant the minsetts directly to the field and provide mulching. At the same time, planting some minisetts in nursery beds/bags will help in gap filling of unsprouted ones in field.

The land is thoroughly prepared. Pits of 30 cm depth are prepared and filled with 1 kg FYM and top soil. Minisetts of 100 g are planted at the centre of the pit with bud portion facing upwards. Spacing of 60 x 45 cm is recommended, compared to 90 x 90 cm in conventional method. As a result, 37,000 plants could be accommodated in one ha. Minisetts sprout in 2-3 weeks. If irrigation is available, minisett can be planted at any time. In case of basal rot disease, drenching of 0.05% carbendazim solution may be carried out. From 100 g minisett, corms of weight 600 g-1.5 kg could be obtained. Rate of multiplication is 1:15 in minisett method as against 1:4 in conventional method. Also, this method will reduce the requirement of initial seed material and give more returns to the seed producer by sale of seed corms compared to ware corms.

Quality standards for selection of source seed material

- In a seed lot, corms not conforming to size (500 g or 750 g as the case may be) should not exceed 5% (by number).
- Seed corm should be clean, healthy and conforming to varietal characteristics. Those not conforming to character of variety shall not exceed 0.1% for certified seed.
- Cut, bruised, irregular, cracked corms damaged by insects (other than scale insects) shall not exceed more than 1%.
- There should not be any visible symptom of corm infested with scale insects/ nematodes for use as planting material.

Storage standards

- Keep the planting material upright side under shaded condition with proper ventilation.
- Moisture content should be 60-70%.

Quality standards of elephant foot yam in the field

- Minimum three field inspections are recommended during the entire crop period for monitoring the quality of planting material.

Isolation distance: Seed fields shall maintain minimum isolation distance for foundation seed and certified seed. The details of isolation distance and maximum permissible limits of off types, pest and disease for foundation seed and certified seed are given in Table 3 and 4.

Table 3. Isolation distance for seed fields

Contaminants	Minimum distances (m)	
	Foundation seed	Certified seed
Fields of other varieties	5	5
Fields of the same variety	5	5

Table 4. Permissible limits of off-types, pest and disease

Factor	Maximum permitted (%)*	
	Foundation	Certified
Off-types	0.050	0.10
Plants showing symptoms of dasheen mosaic	1.0	5.0
Plants infected by collar rot (*Sclerotium rolfsii*) disease	None	None
Plants infested with scale insects	None	None
Mealy bug	None	None
Nematodes	None	None

*Standards for off-types shall be met at final inspection and for designated disease and insects at each inspection. *Note:* 1. All Off-types, diseased and insect infested plants shall be rogued out alongwith corms and destroyed. 2. Gaps in the seed field shall not be more than 10%.

Field inspection schedule

A minimum of three inspections shall be made as follows:

1. First field inspection shall be made at 90 days, check germination, sprouting, pest and disease incidence and off-type plants.
2. Second inspection shall be made at 150 days after planting, to verify off-types and incidence of pest and disease.
3. Third inspection at 200 days after planting or at appropriate maturity stage depending on the crop duration of the variety concerned to verify off types, infestation of pest and diseases and other relevant factors.

Decentralized seed multipliers (DSM)

Since 2021, two avenues have been made available for startups to produce high-quality planting material: FPOs (Farmer producer companies) and progressive farmers who can register with DSM (Decentralized Seed Multiplier) or commercial seed growers. This system involves the multiplication of seed material from released and pre-released

varieties through collaboration with progressive farmers to ensure the distribution of planting materials to those in need. Currently, eleven EFY growers have registered as DSM participants.

Agro-techniques

Planting season

Generally, the crop is planted during February end to second week of March months for rain fed crop. The corms undergo a dormancy period of 45-60 days and it sprouts in April-May with the onset of pre-monsoon showers. If assured irrigation is provided, the crop can be planted during any time of the year.

Land preparation

Ploughing for good soil turning followed by pit formation is the traditional method of land preparation. The pit size should be of 60 x 60 x 45 cm^3.

Pit preparation

Planting method

The top soil dug out is then mixed with farmyard manure or compost @ 2-2.5 kg/pit and the mixture is put back into the pit prior to placing the planting material over it. The planting material is placed vertically in the pits and then covered with soil and compacted lightly.

Spacing

A comparatively wider spacing of 90 x 90 cm is ideal for planting wherein 12,345 plants could be accommodated in one hectare. At ICAR-CTCRI significantly superior corm yield was obtained with 90 x 90 cm spacing (Table 5). The crop is planted shallow as the crop has most of its feeder roots on the surface and moreover deep planting would make harvesting operations difficult. Spacing followed in various elephant foot yam growing states is given in Table 6.

Table 5. Effect of spacing on corm size and yield

Spacing (cm)	Corm size (kg)	Corm yield (t/ha)
60 x 60	2.03	56.5
90 x 90	4.79	59.5
120 x 120	6.88	47.8

Table 6. Spacing followed in various elephant foot yam growing states

State	Spacing followed (cm)	Size of seed material used (g)
Andhra Pradesh	60 x 60	500-750 during Kharif
	60 x 45	300-400 during Rabi
Karnataka	90 x 90	750-1000
Maharashtra	75 x 75	500
Odisha	75 x 75	500
West Bengal	75 x 75	500-600
Assam	90 x 90	500
Bihar	75 x 75	500
Jharkhand	90-100 x 90-100	1000
	60 x 60	500
Chhattisgarh	90 x 90	500
Uttar Pradesh	90 x 90	750-1000
	75 x 75	500
	60 x 60	400
Gujarat	90 x 90	500
	60 x 60	250
Himachal Pradesh	90 x 90	250-500
	60 x 60	<250

Gap filling

The field should be inspected for any areas where EFY plants have not emerged 90 days after planting, and in such cases, these areas can be replaced with new corms. These replacement corms should have been treated and stored properly. It's essential to ensure that the corms used for gap filling are in a healthy and disease-free condition, free from any injuries or wounds.

Mulching

It is advisable to provide mulching using dry leaves, green manure crops, etc. This will help to retain the moisture in the soil, regulate soil temperature as well as control weed infestation. Alternatively application of weed mat also could be followed.

Nutrient management

Nutrient uptake

EFY is a voracious feeder and hence for the exploitation of its full yield potential, adequate plant nutrients, especially N and K, should be made available to the crop. Further, efficient nutrient management is very much important to maintain the soil health. Either nutrient deficiency or toxicity will cause quantitative and qualitative loss. A crop of EFY is capable of producing 33 tonnes corms per hectare and removes 128.8 kg N, 23.6 kg P and 239.6 kg K per ha.

Plant and soil sample collection for analysis

Plant samples for analysis is usually done during the peak/grand vegetative growth of the crop (4-5 MAP). The leaflets from the leaf canopy can be taken randomly so as to get around 100 g leaf fresh weight. These samples after drying and grinding is analysed for nutrients and is compared with critical nutrient concentration (Table 7) to assess the deficiency/sufficiency of particular nutrients.

Soil samples are usually taken at the time of land preparation from a depth of 0-20 cm. If regular sampling needs to be done during the cropping period, it can be taken from the interspaces of the pits.

Table 7. Critical nutrient concentration in the leaf tissues of elephant foot yam

Nutrient	Critical nutrient concentration
N (%)	4.05
P (%)	0.55
K (%)	3.82
Ca (%)	0.33
Mg (%)	0.65
Fe (µg/g)	689
Cu (µg/g)	14
Mn (µg/g)	238
Zn (µg/g)	121

Essential nutrients and deficiency symptoms

The commonly observed nutrient deficiencies in EFY and their management are given in Table 8.

Table 8. Essential nutrients, deficiency symptoms and management

Nutrient	Deficiency symptom	Management
 Nitrogen	▪ General stunted growth and yellowing affecting lower leaves. ▪ In severe cases necrosis and drying up of the older leaves and incidentally the whole plant gets dried.	▪ Application of the recommended dose of FYM @ 25 t/ha and N @ 100 kg/ha. ▪ After the occurrence of the symptom, foliar application of 0.1% urea to regain general vigour of the plant.

 Potassium	▪ Yellowing of the crop with tips and margins of the leaflets turning dry resulting in complete drying and death of the crop.	▪ Application of FYM @ 25 t/ha along with K @ 150 kg/ha. ▪ After the occurrence of the symptom, foliar application of 1% potassium sulphate is effective.
 Magnesium	▪ Interveinal chlorosis of the leaflets later changing to complete drying up of the crop.	▪ Application of dolomite @ 2 t/ha or $MgSO_4$ @ 80 kg/ha at the time of planting. ▪ After the occurrence of the symptom, foliar application of $MgSO_4$ @ 0.5% can help to recover the crop.
 Boron	▪ The symptom is noticed due to excess application of B through soil and foliage. ▪ Distorted growth of the plant with irregular and dwarf stature of the crop with tapering of the pseudostem. Thin, pale and unhealthy appearance of the crop. ▪ Later though the plant dry up it will come up and grow as a distorted plant yielding very poor.	▪ Need based soil application of B based on soil test. ▪ Application of B in soil @ 15 kg/ha Borax, if the soil status is below 0.5 ppm ▪ If foliar application of B is done through soluble boron, the spray solution concentration should be very precise ranging from 1-5 g/l based on the stage of plant growth, extent of manifestation of the deficiency symptom and the status of soil B. Requirement of water will be 500-675 l/ha depending upon the crop canopy.

Blanket recommendation

Different approaches have been standardized to manage the nutrient requirement. ICAR-CTCRI has come out with the general recommendation of FYM @ 25 t/ha and N, P_2O_5 and K_2O @ 100:50:150 kg/ha. Nutrient recommendations for major EFY growing states are given in Table 9.

Table 9. Nutrient recommendations for major EFY growing states

State	FYM (t/ha)	NPK (kg/ha)
Tamil Nadu	25	80:60:100
Andhra Pradesh	25-30	250:60:250
Karnataka	25-30	80:60:100
Maharashtra	NA	80:60:80
Orissa	10	120:60:120
West Bengal	25-30	80:60:100
Bihar	15	80:60:80
Jharkhand	10-15	100:60:80
Chhattisgarh	20-25	100:50:150
Uttar Pradesh	20-25	100:80:120
Himachal Pradesh	20-25	100:80:100

Time and method of application

Traditionally fertilizer is applied in two splits, where full P, half of N and K in first split and half N and K in second split. This coincides with the first and second weeding and earthing up operations which normally is at 45 and 75 days after planting, respectively. It is essential to ensure availability of sufficient moisture in the soil at the time of fertilizer application. The fertilizer is applied around the base of the crop after removing the mulch cover. A light earthing up is done after which the mulch is replaced. It may be ensured to avoid cut/damage to the pseudostem and the fertilizer coming in direct contact with the stem of the plant.

Integrated Nutrient Management (INM) package of secondary and micronutrients

The INM package comprising of liming material, secondary and micronutrients include

- Application of dolomite @ 2 t/ha as basal dose.
- Soil application of $MgSO_4$, $ZnSO_4$ and borax/soluble boron @ 60-90, 20-30, 10-15 kg/ha, respectively, depending upon the soil status and soil critical level of these nutrients either independently or together.
- Foliar application of Zn EDTA (0.5%), soluble boron (0.1%) and $MgSO_4$ (1%) independently depending upon its requirement based on soil nutrient status or manifestation of nutritional deficiency symptoms thrice, i.e., during the peak vegetative growth stage (4-5 MAP), followed by corm bulking stage (5-8 MAP) at an interval of 20 days.

Site Specific Nutrient Management (SSNM)

Site-Specific Nutrient Management (SSNM) is a strategy that tailors nutrient supply to plants based on their specific spatial and temporal requirements. The goal of SSNM is to empower farmers to adjust fertilizer use in real-time to bridge the gap between

crop nutrient needs and what's naturally available from sources like soil, crop residues, organics, and irrigation water. By applying nutrients at the right rates and timings, SSNM aims to boost farmers' profits and enhance nutrient efficiency across different spatial and temporal scales, while also preventing excess nutrient runoff into the environment.

Conventional fertilizer recommendations, whether based on general guidelines or adjusted through soil testing, do not consider factors like regional yield potential, crop varieties, yield goals, or nutrient interactions. The equations used for adjusting fertilizers based on target yields (STCR equations) are not universally applicable to different soil conditions. Furthermore, these methods do not consider nutrient interactions based on Liebig's law of minimum. To address these limitations and close the yield gap, the most viable alternative is to develop more advanced, knowledge-based, and computer simulation model-driven approaches for site-specific nutrient management (SSNM). These approaches account for both the spatial and temporal variations in soil and plant characteristics. The SSNM fertilizer recommendations for elephant foot yam for different growing areas and yield targets are shown in Tables 10-12.

Table 10. Zone specific SSNM recommendations for elephant foot yam in Kerala state, India (kg/ha)

AEU* No.	Yield target (t/ha)	N	P	K	Ca	Mg	Zn	B
1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 20, 21, 22, 23	40	80	30	120	40	20	2.5	1
17	40	100	30	150	40	20	2.5	1
4, 14	40	100	30	180	40	20	2.5	1
16	40	50	30	150	40	20	2.5	1
18, 19	40	50	20	80	40	20	2.5	1

* AEU - Agro Ecological Unit

Table 11. SSNM recommendations for elephant foot yam in India based on calibrated QUEFTS model

O.C (%)	Yield target (t/ha)				Available P (kg/ha)	Yield target (t/ha)				Available K (kg/ha)	Yield target (t/ha)			
	30	40	50	60		30	40	50	60		30	40	50	60
	N rate (kg/ha)					P_2O_5 rate (kg/ha)					K_2O rate (kg/ha)			
Below 0.5	80	100	120	--	Below 10	50	75	100	--	Below 180	120	180	240	--
0.5-0.8	50	80	100	120	10-20	30	50	75	100	180-280	80	120	180	240
0.8-1.2	25	50	80	100	20-30	20	30	50	75	280-360	40	80	120	180
Above 1.2	20	25	50	80	Above 30	10	20	30	50	Above 360	30	40	80	120

Table 12. Zone specific SSNM recommendations for elephant foot yam in major growing areas of India

State	Region	Yield target (t/ha)	N	P	K	Ca	Mg	Zn	B
Kerala	All districts	40	80	30	120	40	20	2.5	1
Tamil Nadu	Tirunelveli	40	100	50	100	40	20	2.5	1
Tamil Nadu Bihar	Erode Samastipur Vaishali Begusarai	50	80	50	100	40	20	2.5	1
Bihar	Muzaffarpur	50	80	75	100	40	20	2.5	1
West Bengal	South 24 Parganas North 24 Parganas Nadia	50	100	50	80	5	2.5	2.5	1
Andhra Pradesh	West Godavari Guntur	50	100	75	80	5	2.5	2.5	1
Andhra Pradesh	Krishna	50	80	50	100	5	2.5	2.5	1
Gujarat	Navsari	40	100	50	80	5	2.5	2.5	1

Customized fertilizers (CF) mixture

Custom-made mixed fertilizers, produced in accordance with SSNM guidance, can be provided for each specific agricultural zone. These fertilizers can include essential nutrients such as N, P, and K as recommended, and may also be enhanced with additional elements like Mg, Zn, and B to address the specific soil conditions in each zone. The Tables 13-15 illustrates the customised fertilizer formulations for different zones in Kerala and major growing regions in India.

Table 13. Customised fertilizer formulations for elephant foot yam in different zones of Kerala state

AEU* No.	Yield target (t/ha)	N	P	K	Ca	Mg	Zn	B	Rate of application (kg/ha)
1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 20, 21, 22, 23	40	12	4	18	6	3	0.4	0.2	650
17	40	13	4	20	5	2.5	0.3	0.1	750
4, 14	40	16	4	12	6	3	0.4	0.2	600
16	40	8	4	23	6	3	0.4	0.2	600
18, 19	40	10	4	17	8	4	0.5	0.2	500

* Agro Ecological Unit

Table 14. Customized fertilizer (CF) mixture in coconut intercropping for Kerala

Sl. No.	Materials	Composition	Rate of application (g/kg or kg/t)
1	Urea	N-46%	50.1
2	Di ammonium phosphate (DAP)	N-18%, P_2O_5-46%	260.9
3	Muriate of potash (MOP)	K_2O-60%	400
4	Magnesium sulphate ($MgSO_4$)	Mg-16%	156.3
5	Zn sulfate (Mono) ($ZnSO_4$)	Zn-33%	37.9
6	Borax	B-10.5%	38.1
7	Filler (Lime/dolomite/any inert material)		56.7

If DAP is not available, mix 103 g or 103 kg urea (in addition to 50.1g /50.1 kg urea) and 600 g or 600 kg super phosphate for each kg or ton of the CF mixture. The rate of application is 625 kg/ha and can be applied @ 51 g/plant at 45-60 days after planting, followed by top dressing with urea and MoP @ 33 and 21 g/plant, respectively within 30-45 days after first application. This can be used in all AEUs of Kerala.

Table 15. Customised fertilizer formulations for elephant foot yam in major growing areas of India.

State	Region	Yield target (t/ha)	N	P	K	Ca	Mg	Zn	B	Rate of application (kg/ha)
Kerala	All districts	40	12	4	18	6	3	0.4	0.2	650
Tamil Nadu	Tirunelveli	40	13	6	13	5	2.5	0.3	0.1	750
Tamil Nadu Bihar	Erode Samastipur Vaishali Begusarai	50	11	6	14	5	2.5	0.3	0.1	700
Bihar	Muzaffarpur	50	9	8	11	5	2.5	0.3	0.1	900
West Bengal	South 24 Parganas North 24 Parganas Nadia	50 40	14	7	12	0.7	0.4	0.4	0.1	700
Gujarat	Navsari	40	14	7	12	0.7	0.4	0.4	0.1	700
Andhra Pradesh	West Godavari Guntur	50	12	9	10	0.6	0.3	0.3	0.1	800
Andhra Pradesh	Krishna	50	12	7	15	0.7	0.4	0.4	0.1	650

Sree Poshini

Sree Poshini, a mobile app developed by ICAR-CTCRI, is now accessible for free on the Google Play store. This user-friendly app is designed to assist tuber crop farmers, including those cultivating elephant foot yam, in determining their fertilizer needs using SSNM technology.

Foliar multi micronutrient fertilizer

ICAR-CTCRI has developed a multi micronutrient formulation containing all the micronutrients essential for elephant foot yam. This customized liquid micronutrient formulation is commercially available in the market as "Micronol-Elephant foot yam special". It may be sprayed @ 5 ml per litre thrice during 2nd, 3rd and 4th month after planting for best results.

Micronol-Elephant Foot Yam special

Water management

The crop is mostly raised as a rainfed crop. Wherever the crop is raised under irrigated conditions, a light irrigation should be given immediately after planting to get uniform sprouting and subsequent irrigation should be given depending on the requirement of plants. Water logging should be avoided. At 4-6 months after planting, coinciding with corm bulking phase is the most critical and enough soil moisture should be ensured during this phase to reduce yield loss. However, a dry spell towards later stages helps in maturity of corms. The water requirement is 4.3-4.5 mm/day and the water productivity is 4.2 kg/m^3. On an average the crop requires 150 to 200 litres of water per 40 m^2 (one cent) per day, depending on the local weather and soil conditions. Mulching with porous ground cover mat in the interspaces of elephant foot yam helps in soil moisture conservation and reduction of the irrigation water requirement to 50%.

In Andhra Pradesh, which is the leading producer of elephant foot yam in India, the crop is grown in paddy fields of East and West Godavari districts, where the water requirement is met through canal irrigation. There are two distinct cropping seasons viz., *Kharif* from April-June to December-February and *Rabi* from November-December to May-June.

Weed management

The critical phase of crop-weed competition is between 1 and 5 months after planting coinciding with the active crop growth stage and corm bulking stage (4-6 months). Hand weeding is the conventional weed control method, done monthly up to 4 months after planting. Each weeding is followed by earthing up. Due to high cost of hand weeding, and lack of labour during peak season, farmers resort to herbicides for control. Planting at wider spacing, coupled with the unique plant morphology (erect single

pseudostem), allows herbicide application up to 4 months after planting (until complete cover of foliage). Application of glyphosate (6 ml per litre water) with protective gear between 1 and 3 months after planting effectively controls weeds and the dying weeds act as mulch. Pre-emergence application of pendimethalin/oxyflourfen (3.0 ml per litre water) followed by two applications of glyphosate (6 ml per litre water) with protective gear as post-emergence produces higher yields, and increases soil organic carbon content. Nurserymen mat or perforated ground cover mat mulch could be a good weed management option in the place of hand weeding in elephant foot yam. When labor is scarce, two manual weeding at 30 and 60 days after planting (DAP) + post-emergence application of glyphosate with protective gear (at 90 DAP) (6 ml per litre water) can be a good weed management option. To prevent herbicide resistance in weeds, weed management with cultural practices like crop rotation is recommended. Use of suitable intercrops during the initial months, post-emergence application of herbicides, or ground cover mulching may reduce crop-weed competition and enhance corm yield.

Severity of field bindweed (*Convolvulus arvensis*) in elephant foot yam

Effective weed management with perforated ground cover mat in elephant foot yam

Organic farming

The growing public concern about environmental and personal health issues have generated great consumer interest in organic farming and organically produced foods. Protocols for organic production of elephant foot yam are briefly dealt with.

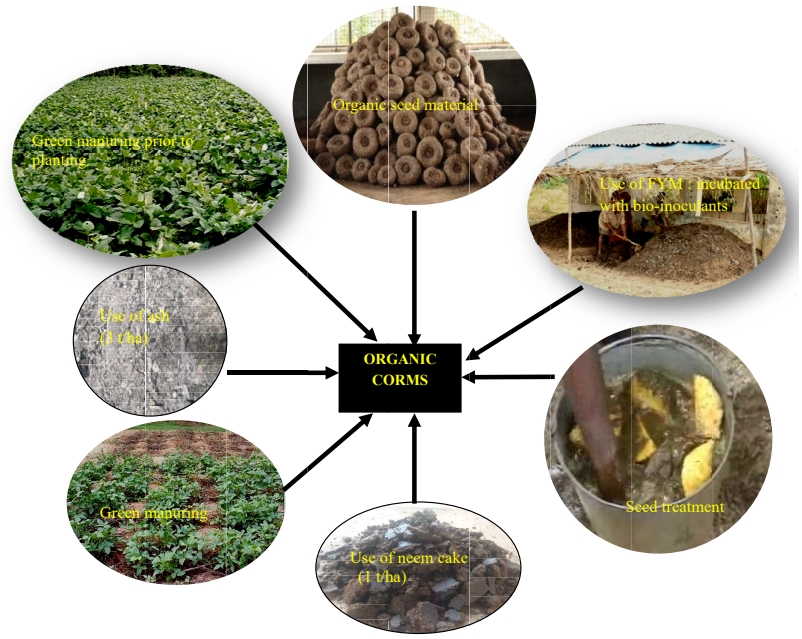
Organic package for elephant foot yam

Raise green manure cowpea (seed rate @ 20 kg ha^{-1}) prior to EFY and incorporate green matter at 45-60 days. Use organically produced planting material. Treat corm pieces of 500-750 g with slurry containing cowdung, neem cake and *Trichoderma harzianum* (5 g per kg seed) and dry under shade before planting. Apply *Trichoderma harzianum* enriched FYM @ 36 t/ha (3 kg per pit) in pits at the time of planting (FYM: neem cake mixture (10:1) inoculated with *Trichoderma harzianum* @ 2.5 kg per tonne of FYM neem cake mixture. *Trichoderma* can be multiplied in FYM alone but it will take 15 days to form sufficient inoculum as against 7-8 days, if neem cake is also used along with FYM. This is effective against collar rot caused by *Sclerotium rolfsii.* Apply neem cake @ 1 t/ha (80-85 g per pit) in pits at the time of planting. Inter-sow green manure

Intersowing of green manure cowpea, cost-effective technique in organic farming

Luxuriant crop growth of green manure cowpea

Organic farming of elephant foot yam



Essential components of organic elephant foot yam production

cowpea (seed rate @ 20 kg/ha) between EFY pits and incorporate green matter in pits at 45-60 days. The green matter addition from the two green manure crops should be 20-25 t/ha. Apply ash @ 3 t/ha (250 g per pit) at the time of incorporation of green manure in pits. Apply *Trichoderma* enriched vermicompost @ 150 g per plant twice after weeding and interculturing as a precaution to avoid collar rot infection. Remove the collar rot infected plants and apply *Trichoderma* enriched vermicompost @ 150 g per plant in the collar region of the adjoining healthy plants.

Cropping systems

Tropical tuber crops, especially elephant foot yam can be cultivated in association with plantation crops like coconut, arecanut, coffee, rubber and fruit crops like banana, mango, litchi etc., as these crops are adapted to the same ecological conditions as perennial trees. In such a system, the main crop provides cash income, tuberous intercrop serve as high energy secondary staple to the farm family and feed for farm animals, behave as insurance crop against risk and natural calamities, enhance the resource use efficiency, ensure food security, augment net income and enhance employment opportunities.

Coconut + elephant foot yam

Performance of EFY, as intercrops in coconut garden has been thoroughly researched and production technologies under intercropping situation has been standardized. It can be intercropped at any age of the coconut palm. Varieties suitable for intercropping in coconut gardens are Sree Padma and Gajendra. About 9000 plants can be accommodated in one ha as intercrop at a spacing of 90 x 90 cm, leaving the 2 m radius from the base of coconut palm. Nutrient recommendation is FYM @ 20 t/ha and NPK @ 26:20:33 kg/ha.

Arecanut + elephant foot yam

The productivity of the crop in association with arecanut palms was evaluated in a number of field experiments. Higher fresh corm yield was obtained as intercrop in arecanut gardens. About 7000 plants/ha could be accommodated at a spacing of 90 x 90 cm, leaving 1 m radius from the base of the palms. Care should be taken to manure both the main crop as well as the intercrop separately and adequately.

Banana + elephant foot yam

Studies conducted at ICAR-CTCRI indicated that in between two rows of *Nendran* banana spaced at 3.6 x 1.8 m, three rows of EFY could be planted at a spacing of 90 x 90 cm to accommodate 8000 plants/ha. In such a system the farmyard manure, N and P dose can be reduced to 50% for individual crops. Hence for EFY, FYM @ 12.5 t/ha and NPK @ 50:25:150 kg/ha is only needed. For Nendran banana, FYM @ 5 kg and NPK @ 95:58:300 g is sufficient for each plant.

Coconut + elephant foot yam

Banana + elephant foot yam

Other fruit/tree crops + elephant foot yam

The crop is most ideal for intercropping in robusta coffee, mango, sapota and litchi orchards. It is a profitable intercrop in robusta coffee producing yield of 18 t/ha. EFY is a feasible intercrop in rubber during the early stages.

Elephant foot yam and pulse crops

Pulses like green gram, black gram and soybean can be intercropped in EFY, but with slight yield reduction of 9% in elephant foot yam. Of the pulses, soybean and black gram are suitable. Intercropping of EFY var. Gajendra with soybean under full fertility level of both the crops is a feasible option. The system enables higher yield (66.40 t/ha), equivalent energy (239.91 x 10^3 MJ/ha), production efficiency (247.30 kg/ha/day), corm equivalent yield (66.77 t/ha), higher net income (₹ 10,09,856 per ha), B:C ratio (3.20) and added profit of ₹ 2,33,164 ha^{-1} over sole cropping of elephant foot yam var. Gajendra (46.48 t/ha, 167.33 x 10^3 MJ/ha, 172.45 kg/ha/day, 46.48 t/ha).

Elephant foot yam + black gram

Elephant foot yam + green gram

e-Crop based smart farming

Electronic Crop (e-Crop) is an IoT device developed by ICAR-CTCRI for Smart Farming (SF). This device helps to give real-time agro advisory of any crop to reduce yield gap and to achieve targeted yield. Weather parameters of the day, the potential yield that can be achieved by the crop after its stipulated duration as per its present crop condition and anticipated weather scenarios, N, P, K and moisture required to be applied to achieve this targeted yield etc. are part of the advisory.

Through *e-Crop* based smart farming (eCBSF), the increase in yield is obtained at a reduced input application. Nitrogen, phosphorus and potassium fertilizers are required at around 50% of the dosages in traditional farming (TF). Yield of EFY through eCBSF is about 200% of the yield under TF. Yield gap reduction is the main advantage of this technology. The yield gap, which is around 50-60% in TF is reduced to 5-10% under eCBSF. Implementation of eCBSF in the fields is expected to benefit the farmers by more automation as well as increased yield at reduced input application. The yield increase is mainly because the crop is getting the required inputs whenever it needs. It is given as per the requirement of the crop and hence, whatever is given is fully absorbed by the crop without wasting anything and leaving it in the soil, which otherwise might have led to environmental pollution.

Electronic Crop device

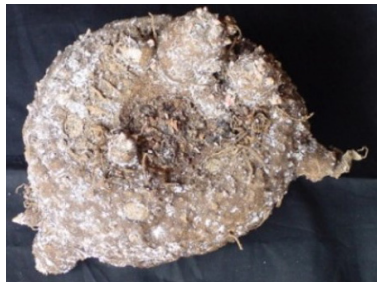
Pest management

Yam mealy bug (*Rhizoecus amorphophalli* Betram)

Mealy bug desaps the leaf and the high incidence causes drying of leaves and withering.

Management

- Make sure that planting material and field are free from mealy bugs.
- Cut and burn the plants, which are severely infested. Whitefly traps are equally good to attract adult bugs.
- Natural predator of mealy bug, *Cryptolaemus montrouzieri* @ 10/plant can be used against the pest.
- Treatment with cassava-based biopesticides, *Shreya* 10 ml/litre followed by *Nanma* 10 ml/litre after a week before storing the corms.



Mealy bug infestation in elephant foot yam

Elephant foot yam (EFY) defoliator

For the last 2-3 years, EFY shoots were attacked by the chrysomelid beetle, *Sphenoraia hopei* in many parts of Kerala. They feed on the shoots and also bore in them. If attack is severe the whole plant will be dried. The pest could reduce the crop yield substantially in the future, and become a menace to the farmers.

Damage by the defoliator *Sphenoraia hopei* adult

Management

Weeding and clean cultivation are important in its management. Study showed that, spraying and drenching of quinalphos 25% EC @ 2ml/litre can control the pest.

Wireworm

In the last few years, wire worms/ click beetles (Elateridae) were attacking EFY in Kerala by boring into the collar region and corms. It can drastically reduce crop yield and also market value.

Wireworms infecting EFY pseudostem

Management

- Ploughing the field before planting and adequate irrigation can provide the desired effect against the pest.
- In the field, where the wire worms are observed, further pest attack could be prevented by flooding the field for one week before planting.
- Drenching with fipronil 5% @ 1.5 ml/litre or chlorpyrifos 20% EC @ 2 ml/litre can manage the pest to some extent.

Nematodes

Among the tuber crops, EFY is one of the most susceptible crops to nematode infection. They cause both qualitative and quantitative yield losses and make the corms unfit for marketing and consumption. High levels of nematode infestation have been observed from the elephant foot yam corms in Andhra Pradesh, Kerala and Tamil Nadu. They are field cum storage pest as the infestation continues even after harvest. They cause around 25-30% reduction in weight during storage. Root

Infective juvenile of *Meloidogyne incognita*

knot nematode, *Meloidogyne incognita* and lesion nematode, *Pratylenchus coffeae* are the two important nematode pests of EFY.

Spread

Primary spread is through infected planting material. Secondary spread is through irrigation from infected field, use of farm implements and movement of animals from infected fields to uninfected fields.

Nematode infested EFY

Symptoms

The common above ground symptoms associated with nematode damage are yellowing of leaves, day wilting and stunting of plants. The below ground symptoms are knots/ galls on corms and cormels, malformed and distorted corms, black discoloration of tissues and tuber rot.

Management

- Deep summer ploughing during April- May.
- Fallowing after crop season.
- Selection of nematode free planting material.
- Crop rotation with non-host crops, *viz.,* maize, sorghum.
- Rotating the place of cultivation each season within the farm.
- Growing of trap crop, sweet potato cultivar Sree Bhadra and antagonist crop marigold and destruction of roots after cropping season.
- Burning and destruction of severely infested corms and plants.
- Treatment of corms with *Trichoderma* enriched cowdung slurry at the rate of 5g/kg corm three days prior to planting.
- Apply *Trichoderma* enriched FYM at the rate of 2.0-2.5 kg/pit at the time of planting.
- Use of newer nematicides, Fluensulfone 2% GR @ 1g per plant or fluopyram 34.48% SC @ 0.5 ml per plant.

Disease management

Collar rot

The most prevalent and harmful disease affecting EFY is collar rot caused by *Sclerotium rolfsii*. Although this disease is typically seen in the later stages of crop development, the pathogen has the ability to infect plants at any time. An intercultural operation's injury to the collar area increases the risk of taking infection.

Symptoms

Just above the soil surface, water-soaked lesions start to develop on the stem, and the leaf begins to turn yellow from the tip. Eventually, the entire plant turns yellow as the yellowing extends downward gradually. The plant finally falls as a result of the pseudostem shrinking, which cause substantial yield loss. The pathogen's fruiting bodies, or sclerotia, are visible as a thick, white mycelial mat with globular, dark-brown mustard seed-like structures all over the infected tissues.

Collar rot symptom

Mycelia and sclerotia in collar region

Fallen plants due to collar rot

Causal organism and spread

The disease is caused by *Sclerotium rolfsii*. These sclerotia allow the pathogen to live during the off-season. The prevalence of the disease rises when elephant foot yam is grown repeatedly in the same field. The pathogen can live on a variety of different hosts. Predisposing conditions for disease occurrence include frequent rains, warm, humid weather, heavy soils, high levels of organic matter, poor drainage, and wounds brought on by insects, fertilisers, and tools.

Integrated disease management

- Use of disease-free planting material, since most of the pathogens in storage affect the crop in field also.
- Removal of infected plants and providing improved drainage.
- Treat the corms in mancozeb + carbendazim fungicide @ 2g/kg corm before planting.
- Drenching the plants twice with 0.2% of combination fungicide (mancozeb + carbendazim) immediately after intercultural operations.
- Remove the infected plants and give additional drenching to surrounding plants with the combination fungicide.

Organic Management

- Treating the corms three days before planting in cow dung slurry amended with *T. asperellum* @ 5g/kg corm.
- Application of *T. asperellum* enriched FYM @ 2.0-2.5 kg/pit at the time of planting.
- Application of *T. asperellum* incorporated vermicompost @150 g/plant at the collar region immediately after intercultural operations and removal of infected plants and additional application to surrounding plants with *T. asperellum* incorporated vermicompost.

Mosaic disease

Every elephant foot yam-growing region is affected by this disease, which can reduce yields by up to 38%. The mosaic incidence is 5% in India. Typically, the initial leaf remained symptom-free while the second or third leaves displayed mosaic symptoms. The plants remained very weak in these situations, and all the subsequent leaves likewise had severe symptoms when the first leaf displayed mosaic signs. However, the signs of yellowing and vein clearing are more prevalent in cases with mild illness.

Mosaic symptoms

Yellowing and leaf narrowing

Symptoms

The mosaic-infected plants are generally dwarfed and chlorotic in appearance and exhibit mosaic mottling which is more pronounced in young leaves. The leaflets become narrow and symptoms of leaf distortion like leaf strapping, rat tailing/shoe string, puckering and upward curling of leaf lamina are prominent in severely infected plants.

Causal organism and spread

This disease is caused by *Dasheen mosaic virus* (DsMV) which belongs to the *Potyvirus*

group. This disease is mainly transmitted through infected planting material and in field through aphids (*Myzus persicae* or *Aphis gossypii*).

Management

- Selection of planting material from healthy plants which are free from DsMV infection.
- Growing of plants obtained through meristem tip culture.
- Roguing of infected leaves, self-sown elephant foot yam or taro plants.
- Spraying of imidacloprid 17.8 SL (0.3 ml/l) or thiamethoxam 25 WG (0.3-0.4 g/l) at 14 days interval to control the vector.

Postharvest rot/ corm rot

Post-harvest rot can directly cause 25-30% crop loss and additional loss by increasing the susceptibility of the plants to pathogens in field. The corms are prone to several postharvest diseases due to their high moisture content and starch. Besides damaging seed corms, these pathogens also inhibit sprouting and make the plants more prone to field diseases. The mechanical injury to the corms during harvesting and transportation makes them vulnerable to various rotting fungi and bacteria. Pre-harvest infection in the field, infected soil adhering to the corms, nematode damage and high moisture content of the corms stimulates physiological and microbiological spoilage.

Symptoms

The affected corms show discoloration, softening of the tissue and rotting. External symptoms may or may not be there. The symptom varies with the organism(s) involved with the rotting. In some cases, white powdery appearance will be seen on the outer surface of the corm. Many a times, the surface of the corm becomes completely rotten. Inside tissues shows brown/black colour spots and the adjoining spots coalesce and form

Rotting of corms

Powdering of corms

bigger irregular patches. In some cases, inner portion of the corms show putrefaction of the tissue with brown to black discolouration. Chocolate brown to brown colour oozing from the lesions was also observed. Affected portion may turn to powdery mass of tissue.

Causal organism and spread

Thirteen fungi, viz., *Sclerotium rolfsii, Lasiodiplodia theobromae*, *Rhizopus oryzae*, *Cunninghamella elegans, Rhizoctonia solani*, *Ceratobasidium* sp., *Fusarium* spp. (3), *Colletotrichum gloeosporioides*, *Aspergillus* spp. (3), *Penicillium citrinum* and a bacterium, *Erwinia carotovora* cause the rot. The pathogens spread primarily through infected planting material.

Management

- Minimising the injury to corms during harvesting, transporting and storage.
- By removing infected portion from the corm.
- Storage in a ventilated place.
- Dipping the corms in mancozeb 0.15% or combination fungicide containing mancozeb + carbendazim before storage of the corms. After treatment, dry the corms under shade and store.
- Organic management-Dipping the corms in cow dung slurry mixed with *Trichoderma asperellum* @ 5 g/kg corm or 0.7% *Nanma*, a cassava leaf based bio-pesticide and allowing the corm to dry under shade before storing the corms in ventilated place.

Harvesting and storage

In conventional practice of rainfed cultivation, it will be ready for harvest 8-9 months after planting. In the case of irrigated cropas in Odisha, Bihar, West Bengal and Andhra Pradesh, it is harvested at 6-7 months. For seed corm purpose, the crop is harvested one month after the shoot portion is dried off. On an average, corm yield of 40-50 t/ha can be obtained, based on variety and management practices followed.

Harvesting is done by digging the soil and collecting corms without damage. The corms are cleaned of soil and stored in upright position under shade with proper ventilation. The optimum moisture of corms during storage should be 60-70%.

Storage of seed corms

After curing, the corms need to be stored by spreading them closely in single layer and covering with coarse dry sand in a cool and ventilated place. This should be followed

by periodical removal of damaged corms/portions, if any. This is the best method of storage that ensured minimum decay and weight loss. However, storing in single or double layer without covering dry sand is practiced by most farmers.

Storage of harvested corms on steel racks

Storage of harvested corms on floor

Seed corm moisture loss increased with time in storage and was much higher in the uncovered storage. Locally available materials like dry ash, sand, rice bran, dry soil and saw dust were effective for covering the corms for prolonging shelf life in storage. Seed corms stored in zero energy cool chamber (ZECC) recorded less loss of moisture.

Processing and value addition

In India, the elephant foot yam is usually boiled or baked and eaten as a vegetable. Production of different value added products by applying scientific knowledge to improve the quality of traditional or ethnic food offers better avenues for their value addition, creation of entrepreneurship and round the year availability of shelf stable processed corms in any parts of the world at a reasonable price. The corms of traditional varieties are highly acrid and cause irritation in the throat and mouth due to the excessive amount of calcium oxalate. However, variety Gajendra is free from acridity and is high yielding.

Quick cooking dehydrated corms

The longer cooking time and hard/woody texture of the rehydrated product is a main bottleneck for their widespread use. Being an ethnic food product, the dehydrated corms of EFY with less cooking time and having comparable organoleptic quality in taste and texture of the fresh cooked corms will have great demand in both domestic and export market. The low bulkiness of the dehydrated product also helps to reduce transportation, packaging and storage cost which in turn reduce the price of the final product. Hence the processing technology for the production of dehydrated quick cooking elephant foot yam corms has been developed by ICAR-CTCRI with minimum cooking time. It has been found that 4-6 min cooking time was sufficient to produce good quality dehydrated elephant foot yam product, depending on the raw material and processing conditions.

Raw tubers

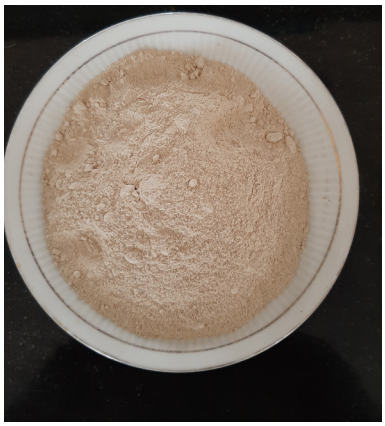
After cooking

Dehydrated tubers

After cooking

Elephant foot yam flour and ready to fry/roast papad

Aroids such as EFY are not exploited for industrial uses as it is cultivated in small pockets and used only as vegetables. Browning (discoloration) and acridity are the major problems in utilizing these corms. Different pre-treatments can be used for its prevention. Among the pre-treatments, soaking in 1% citric acid for 2 h is the best method to avoid browning and acridity in the corms. Papad is one of the popular snack items and it is very tasty so it is used in every Indian diet since older days. To make papad, slices of pre-treated corms are cut and then dried and milled to obtain fine flour. The flour for papad making has been standardized by ICAR-CTCRI as 30% EFY flour + 40% black gram flour + 20% green gram flour. Other ingredients are water, salt, papad masala and oil.



Flour for pappad making

Pappad

Ready to fry fingers


Finger fries

The corms have to be cleaned with tap water and made into shreds using a shredder. Then shreds are to be kept in 1% citric acid for 2 h to avoid the browning and acridity problems. After pre-treatment, the shreds are to be cleaned with tap water and blanched for 10 min to kill harmful microorganisms and to prevent undesirable odour. Further shade drying is to be carried out (10-12 h) and the shreads could be stored in HDPE bag. These fingers would be used as ready to fry snacks whenever required.

Ready to cook pasta


Ready to cook pasta

Ready to cook healthy pasta could be made from EFY flour (35%), sooji (45%) and finger millet (20%). It is a healthy breakfast for children, diabetic and obese person and a good source of protein (14.63%), iron (3.45 mg/100g) and calcium (336 mg/100g).

Extruded products

Technology for production of extruded products from elephant foot yam was standardized at ICAR-CTCRI. EFY was conditioned to the moisture content of 12 and 14% and extruded by varying the die temperature as 200, 215 and 230°C. The expansion ratio, bulk density and moisture content of the extrudates varied between 1.57-2.27, 452-705 kg/m^3 and 7.67-8.94%, respectively. The bulk density increased and expansion ratio decreased with the increase in moisture content of the feed flour. The textural properties of the extrudates measured as hardness, toughness, snap force and snap energy values were in the range of 8.76-54.33N, 3.13-36.37Ns, 3.88-7.05N and 0.92-2.31Ns, respectively. Hardness and toughness of the products decreased as the screw speed increased.

Three blends of corm:rice (25:75, 50:50 and 75:25) were prepared and conditioned to 16% moisture content and extruded. The moisture content of extrudates varied from 8.98 to 12.98% and expansion ratio between 2.32-2.92. The product density, bulk density and porosity of the product ranged between 357- 700 kg/m^3, 159-347 kg/m^3 and 2.29-46.37%, respectively. The hardness of the extrudates varied from 9.8 to 19.4N, toughness from 24.2-54.4Ns, crispness from 9.8-19.4N and snap force 12.2-28.7Ns. Water absorption index of the extrudate ranged between 3.81- 6.42 g/g. The best product was obtained for the 50:50 blend processed at 215ºC die temperature and 80 rpm screw speed.

Extruded products from elephant foot yam

Payasam (Suran kheer)

Payasam

Cook the corms in a pressure cooker after peeling and grind well to a coarse paste. Soak the sago in water for a while. Fry the cashewnuts and raisins in a little ghee and keep aside. Grate the coconuts and squeeze out thick milk. Add 4 cups of water and squeeze out thin milk. Add the ground elephant foot yam corm along with the jaggery into a big vessel. Add 50 g ghee. Stir well till the water is absorbed. Add the second thin milk and stir till it is reduced to half. Now add the soaked sago and stir well till the sago is well cooked. Add the fried nuts and raisins also and after through mixing, add the thick coconut milk. Stir well for a while and remove from the fire. Add the cardamom and dry ginger powder and mix well. Nutritional facts per 100 g: Energy-137 Kcal; Protein-1.1 g; Fat-8.0 g.

Masala fry

Wash the elephant foot yam and cut it into equal-sized slices. Combine all of the spices in a bowl with the vinegar, then add the corn flour and salt and combine thoroughly. Then place the sliced corms in the masala that has already been prepared for 15 min. Heat the oil in a skillet, then add the sliced elephant foot yam pieces and fry them.

Masala fry

Chutney

First, peel the elephant foot yam and wash it before cutting it into pieces and cook it in a pressure cooker. In a mixer grinder, combine the green chillies, garlic, tamarind, ginger, coriander leaf, and salt with the elephant foot yam pieces and grind well. Season the chutney in a skillet with oil and serve with rice/chapattis.

Economics and marketing

Economics

Elephant foot yam is grown in India in an area of 42,000 hectares, producing 10.4 lakh tonnes annually. The corms typically cost 25 rupees per kilogram, and the entire elephant foot yam market in India is worth 26000 million INR. The crop produced from farm to fork, offers 410 man days' worth of job potential per ha and promotes sustainability in our nation. Therefore, the EFY sector in our country contributed 17.22 million man days worth of employment in total.

The cost of cultivation of EFY for one hectare is estimated to be ₹ 2.0 to 2.5 lakhs. As EFY is mainly used for edible purposes, the price varies from ₹ 20 to 25 per kg of corms depending on the demand and supply and consumer preferences. Gross income that could be realized from one ha is ₹ 5.00 to 6.25 lakhs.

Marketing

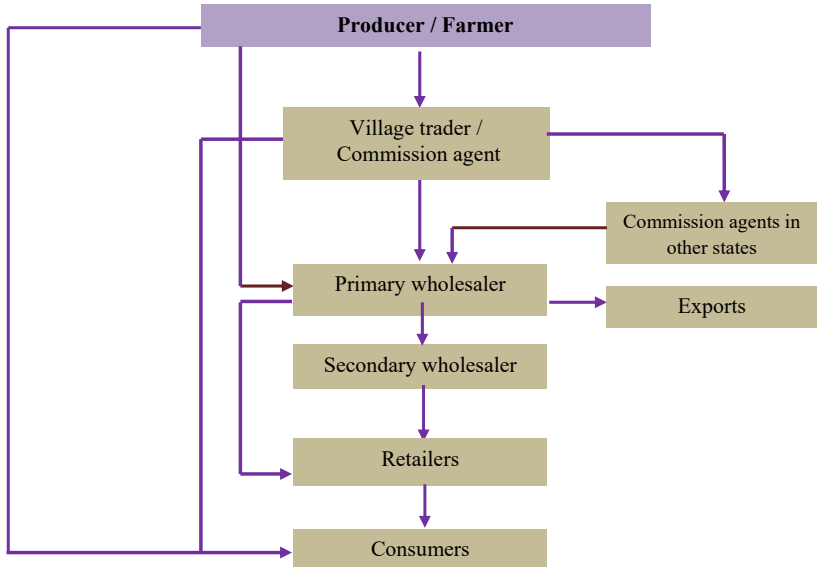
Elephant foot yam are marketed at local places and also to various places of the country viz., Andhra Pradesh, Gujarat, West Bengal, Kerala, Bihar, Uttar Pradesh and Delhi (Table 16). Some quantities are exported to Gulf and European countries. They are mainly consumed as a vegetable.

The schematic diagram of the marketing channels in India is given below.

Table 16. Centres of production and marketing of elephant foot yam.

State	Production centres	Marketing centres
Andhra Pradesh	East Godavari West Godavari Krishna Guntur	Odisha West Bengal Tamil Nadu Maharashtra
Tamil Nadu	Tirunelveli Erode	Tamil Nadu
Kerala	Wayanad Malappuram Ernakulam	Kerala Tamil Nadu
Gujarat	Surat Ahmedabad Navsari Vadodara	Gujarat New Delhi Punjab Himachal Pradesh
West Bengal	24 Parganas Nadia	West Bengal North Eastern states
Punjab	Ferozpur	Jammu Punjab
Uttar Pradesh	Jaunpur	Uttar Pradesh

Market channels of elephant foot yam



Market channel for elephant foot yam in India

Conclusion

Elephant foot yam is a unique and culturally significant crop with both culinary and medicinal purpose. The technical bulletin provides a concise and informative summary of the significance of EFY cultivation, highlighting its nutritional value, cultural importance, adaptability, economic benefits, medicinal uses, and contributions to biodiversity, sustainable agriculture, crop management, value enrichment, economics and marketing. The document effectively encapsulates the key points of the subject matter, making it clear that elephant foot yam is a valuable crop with diverse benefits. This document is well-structured and provides a compelling overview of the importance of promoting and cultivating elephant foot yam in various regions.

Elephant Foot Yam for Food, Health, Wealth and Prosperity

ICAR-Central Tuber Crops Research Institute
Sreekariyam, Thiruvananthapuram 695 017, Kerala, India
Phone: (91) (471) 2598551 to 2598554
E-mail: director.ctcri@icar.gov.in; Website: https://www.ctcri.org