SWEET POTATO

Diamond Jubilee 60 Years ICAR-CTCRI

भाकृअनुप-केन्द्रीय कंद फसल अनुसंधान संस्थान

(भारतीय कृषि अनुसंधान परिषद्)

श्रीकार्यम, तिरुवनंतपुरम 695 017, केरल, भारत

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ICAR-CENTRAL TUBER CROPS RESEARCH INSTITUTE

(Indian Council of Agricultural Research)

Sreekariyam, Thiruvananthapuram 695 017, Kerala, India

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Diamond Jubilee of ICAR-CTCRI

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From the Director

Sweet potato (*Ipomoea batatas* (L.) Lam.,) is considered as a versatile food crop owing to its adaptability to diverse soil and climatic conditions. Sweet potato is one of the important staple food crops in our country among the disadvantaged population and its use is limited in animal feed and industrial applications. In India, it is cultivated in an area of 1.06 lakh ha with a production and productivity of 12.10 lakh tonnes and 10.57 t/ha respectively. The major sweet potato producing states are Odisha, West Bengal, Uttar Pradesh and Kerala which contribute to 76% area and 78% production in India.

The importance of the crop has increased over the years due to the technological interventions by ICAR-CTCRI, AICRP TC centres and other organizations working on sweet potato in India. The crop assumes greater significance in eradication of malnutrition especially orange fleshed sweet potato for managing vitamin A deficiency in tribal settlements of the country. At the global level, the programmes by Harvest Plus and Sweet potato for Profit and Health Initiative (SPHI) are gaining momentum in this regard. The innovative extension programme 'Rainbow diet campaign' by ICAR-CTCRI for popularizing biofortified varieties of sweet potato among farmers for production and consumption in north eastern states, eastern states and tribal areas of southern parts of the country has been a great success and needs to be further strengthened by way of collaboration with other R&D organizations.

During the last 60 years, research and development in sweet potato has led to the release of 21 high yielding varieties with different nutritional quality traits and capacity to manage biotic & abiotic stresses, novel agro-techniques, protocols for quality planting material production, integrated nutrient management, site specific nutrient management, organic farming, water management, weed management, cropping systems, integrated pest and disease management, processing and value addition. I am happy to present the technical bulletin titled 'sweet potato' which covers the above recommended practices to be adopted by the farmers and other stakeholders for realizing higher yield and sustainable income in the long run.

I am sure that this technical bulletin will serve as a valuable reference document to the scientists, developmental professionals, decentralized seed multipliers, farmers, entrepreneurs, policy makers and other stakeholders for applications in the field for maximizing productivity and profitability from sweet potato sector. I congratulate the Chief Editor and Editors for bringing out this publication on time.

20 July 2023

G. Byju

Sweet Potato

Scientific Name: *Ipomoea batatas* (L.) Lam.

Introduction

Sweet potato is a staple nutritious food crop grown in the humid tropical and subtropical regions of the world. It is a dicotyledonous short duration crop (80-120 days) belonging to the family Convolvulaceae. The edible carbohydrate rich roots (tubers) are formed by the secondary thickening of the upper part of some feeder roots. Tubers with different colours such as white, purple, yellow and orange are available and are used either for human consumption or as animal feed. The country of origin is tropical America and spread to south Pacific. Sweet potato tubers are consumed as secondary staples in developing countries after cereals, potato and cassava. It is eaten either as raw or boiled and locally marketed in unprocessed form. The tubers are industrial raw materials for the production of flour and starch, which are used in noodles, pasta and bakery foods including the fried snacks. In some places, it is the mainstay of livestock production for pig and cow (vines and non marketable tubers). Young leaves and shoots are used as green vegetable.

Sweet potato is a hardy crop, adaptable to a wide range of climatic conditions and has the potential to produce tubers even under saline soils and also during flooding. Farmers prefer sweet potato as a less input demanding crop and can be grown profitably under rainfed conditions.

Among the root crops, sweet potato ranked third in 2020 after potato and cassava. Globally, it was grown in an area of 7.40 million hectares (Mha) with a production of 89.49 million tonnes (Mt) and the productivity was 12.09 t/ha. China (49.19 Mt), Malawi (6.91 Mt) and Tanzania (4.43 Mt) are the world's largest producers of sweet potato (FAO, 2023). During 2020 in India, it was cultivated in an area of 0.116 Mha with a production of 1.186 Mt and the productivity was 10.22 t /ha with 28.4% contributed by Odisha and 21.81% by Uttar Pradesh. The major sweet potato growing states include, Odisha (40410 ha), Bihar (20870 ha), West Bengal (20400 ha), Uttar Pradesh (17330 ha) and north eastern states (5300 ha).

The characteristics of sweet potato are presented in Table 1.

Table 1. Characteristics of sweet potato

Planting material (Propagule)	Vines and tubers
Growth period (months)	80-120 days
Optimal rainfall (mm)	750 mm and above
Optimal temperature (°C)	24^0C and above
Drought resistance	Partially
Water logging tolerance	No
Shade tolerance	No
Soil fertility requirements	Medium to high
Seasonality of crop cycle	Yes
In-ground storage life	Good
Post-harvest storage life	Good
Leaves used for animal feed	Yes

Importance

With the introduction of biofortified sweet potato varieties rich in β-carotene (precursor of vitamin A) and anthocyanin (anti-carcinogenic) which can combat micronutrient malnutrition, sweet potato farming has gained momentum in states like Odisha and Karnataka. The biofortified varieties have opened the new 'health-focused food markets' which increased the commercial value and export potential of this crop. The export value of sweet potato in India was Rs. 25.92 million and the export volume was 0.96 million tonnes in 2021 which was exported mostly to Nepal, Maldives and UAE. Emergence of sweet potato as a 'nutritious super food' to eliminate hidden hunger and its associated industrial potential has brought significant changes in the production approaches of sweet potato. Hence, the present focus is for developing 'Good Agricultural Practices' to produce sweet potato tubers suitable for direct consumption and for industrial utilization.

Sweet potato has assumed great significance in recent years as a health food due to the various bioactive principles in its tubers. Sweet potato roots combine the properties of cereals, fruits and vegetables owing to its contents respectively of starch, pectin, and vitamins. Since sweet potato is a good source of non-starch polysaccharides, which play a significant role in the prophylaxis of various diseases such as colon cancer, *Diabetes mellitus*, cardiovascular diseases, hypercholesterolaemia and obesity, its importance is increasingly recognized globally as a health promoting food. The major non-starch polysaccharides in sweet potatoes are cellulose, hemicellulose and pectin and these have the role of 'dietary fibre'. The tubers are rich in micronutrients such as potassium, calcium, phosphorus and vitamin C.

The flesh colour of sweet potato ranges from white to dark orange and purple. The cream, yellow and orange-fleshed tubers contain appreciable amounts of β-carotene (0.013-14 mg/100g on fresh weight basis). Orange fleshed sweet potato offers nutritional security as it forms one of the nature's unsurpassed sources of β-carotene, an essential antioxidant factor of food capable of reducing the risk from night blindness and certain types of cancer. Anthocyanins are responsible for the purple flesh colour of sweet potato. Sweet potato anthocyanins are very good antioxidants and have multiple physiological functions such as radical scavenging and hypoglycaemic activities. In addition, phenolic acids and vitamins such as ascorbic acid (vitamin C) and α-tocopherol (vitamin E) also contribute to the antioxidant activity of purple fleshed sweet potato.

Sweet potato leaves are nutritious but are consumed to a limited level only in certain parts of the world. Sweet potato leaves are a rich source of vitamins, minerals and protein and it can be used as a leafy vegetable. The nutritive value of sweet potato leaves is mainly

attributed to the presence of high levels of antioxidants such as phenolic compounds. Purple coloured sweet potato leaves are one of the richest sources of anthocyanins, which are associated with antioxidant, anti-diabetic and anti-carcinogenic properties.

Nutritional profile

Both sweet potato tubers and leaves are rich in phytochemicals and micronutrients essential for human health.

Sweet potato tuberous roots:

Sweet potato tubers are rich in carbohydrates and the raw tubers contain 6-14% sugars on dry weight basis, which is mainly in the sucrose, glucose, fructose and maltose forms. The dry matter varies from 25.1-38.2% and starch comprises 50-80% of the dry matter. Anthocyanins from the tubers of Bhu Krishna variety has potential antioxidant activity towards 2,2-diphenyl-1-picryl hydrazil (DPPH) radicals with an IC_{50} value of 18.58 µg/ml, whereas, it is 17.47 µg/ml for anthocyanins isolated from the purple leaves of a sweet potato accession (S-1467). The biochemical properties of sweet potato tuberous roots are given in Table 2.

Table 2. Proximate composition of sweet potato tubers

Parameter	Quantity
Proximate composition (Fresh weight basis)	
Dry matter (%)	25.1-38.2
Moisture (%)	64.8-79.7
Total carbohydrates (%)	18.0-28.0
Crude protein (%)	0.7-2.7
Crude fibre (%)	3.0-4.0
Ash (%)	0.73-4.2
Lipids (%)	0.10-0.46
Mineral composition (mg/100g) dry weight basis	
Calcium	17-45
Phosphorous	29-57
Potassium	250-450
Magnesium	18-20
Iron	0.6-1.0

Sweet potato leaves:

They are consumed as a leafy vegetable in certain regions, particularly in Africa, Asia, and some parts of America. The nutritional composition of sweet potato leaves makes them comparable to spinach and other leafy greens. Additionally, sweet potato leaves contain a variety of minerals and vitamins that are beneficial for overall health. The leaves contain several phytonutrients, including flavonoids and phenolic compounds in high levels. These compounds possess antioxidant and anti-inflammatory properties, which can contribute to disease prevention and support the overall well-being of the consumers. The leaves also contain carotenes, such as β-carotene, which serve a precursor to vitamin A.

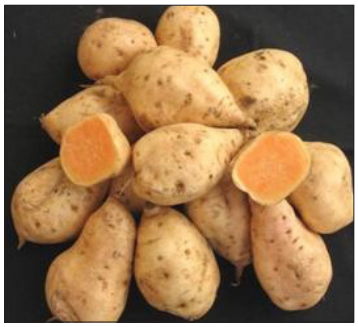
Sweet potato leaves have high protein content, ranging from 17.8% - 30.3% which makes them a valuable source of plant protein. Moreover, it contains, 20% fibre and 1.7% ash. Fresh sweet potato leaves typically provide around 35-52 mg/100 g of carotenes and 63-81 mg/100 g of vitamin C on fresh weight basis. Another noteworthy component found in sweet potato leaves is lutein, a xanthophyll that is known to protect the eyes. Sweet potato leaves are a potential source of lutein, with concentrations ranging from 19-40 mg/100 g. These leaves are particularly rich in minerals such as potassium, calcium, and magnesium. The potassium content can vary from 440-90 mg/100 g, while the calcium content typically ranges from 39-91 mg/100 g. Magnesium levels in sweet potato leaves are around 54.1-65.8 mg/100 g. All these contents are expressed on fresh weight basis. Their nutritional value and health benefits make them an intriguing option that could potentially fill a market niche.

Varieties

1. Bhu Sona

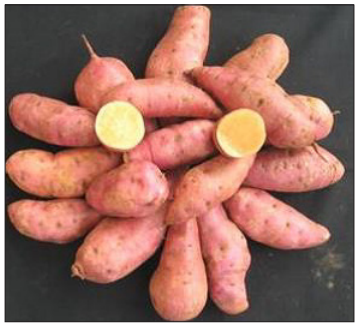
Year of release	:	2017
Pedigree	:	Clonal selection of open pollinated seedling progenies of exotic source
Yield	:	20-24 t/ ha
Duration	:	105-110 days
Suitable growing region	:	Odisha
Key traits	:	Spreading type with pubescent, purple vine with shallow grooves and green emerging leaf, leaf toothed with green petiole, profusely flowering. Storage root round elliptic with yellow skin and dark orange flesh with β-carotene content of 11.5-12.5 mg/100g fresh weight.

2. Bhu Kanti



Year of release	:	2017
Pedigree	:	Clonal selection of introduced lines from CIP
Yield	:	22-24 t/ ha
Duration	:	105-110 days
Suitable growing region	:	Odisha
Key traits	:	Spreading type, green vine with many purple spots and dark green emerging leaf, leaf triangular, profusely flowering. Storage root elliptic with light yellow skin and orange flesh and β-carotene content of 6.5mg/100g fresh weight. Field tolerant to sweet potato weevil, mid season drought and salinity.

3. Bhu Ja



Year of release	:	2017
Pedigree	:	Clonal selection of introduced line from CIP
Yield	:	20-22 t/ ha
Duration	:	100-110 days
Suitable gro wing region	:	Odisha
Key traits	:	Semi compact plant type with green vine and green emerging leaf, leaf toothed and profusely flowering. Storage root round elliptic with pink skin and orange flesh and having β-carotene content of 5.5-6.4 mg/100g fresh weight, tolerant to salinity.

4. Bhu Krishna

Year of release	:	2017
Pedigree	:	Clonal selection of introduced line from CIP
Yield	:	18-22 t/ ha
Duration	:	110-120 days
Suitable growing region	:	Odisha

	Key traits	:	Semi compact plant type with green pubescent vine having purple nodes, emerging leaf bright green with purple edge, leaf triangular and sparse flowering. Long elliptic tuber with dark purple skin and dark purple flesh containing 90mg/100g anthocyanin. Highly tolerant to sweet potato weevil and salinity.

5. Bhu Swami

Year of release	:	2017
Pedigree	:	Òpen pollination and clonal selection from exotic lines
Yield	:	20 t/ ha
Duration	:	105-110 days
Suitable growing region	:	Odisha
Key traits	:	Semi compact plant type having green vine with purple spots and emerging leaf possess purple veins on upper surface, toothed leaf and profusely flowering. Storage root round with white skin and white flesh. Suitable for food and processing with 21% extractable starch. Tolerant to mid season drought. Tubers have excellent cooking quality

6. Kishan

Year of release	:	2005
Pedigree	:	Generated from polycross and the female parent is S-1016
Yield	:	17 t/ ha
Duration	:	110-120 days
Suitable growing region	:	Medium to uplands and hilly areas of Odisha

	Key traits	:	Semi compact with greenish purple vine and emerging leaf green with purple margin, leaf triangular having green petiole with purple near leaf base. Storage root elliptic with reddish purple skin, white rind and creamy white flesh with 18.2% extractable starch. Suitable for food, fodder and starch. It can withstand mid season drought and soil salinity up to 16 dS/ m and perform better in sandy loam and black sandy soils.

7. Sourin

Year of release	:	2005
Pedigree	:	Generated from polycross, and the female parent is accession No. 1162
Yield	:	16.2 t/ha
Duration	:	105-110 days
Suitable growing region	:	Medium to uplands and hilly areas of Odisha
Key traits	:	Spreading nature with mostly purple vine and purplish green emerging leaf, lobed leaf with green petiole and purple spot throughout. Storage root round to elliptic with red skin, white rind and creamy white flesh. Suitable for both *kharif* and *rabi* seasons.

8. Goutam

Year of release	:	2005
Pedigree	:	Generated from polycross and Dhenkanal local (a popular land race) as female parent
Yield	:	19 t/ ha
Duration	:	105-110 days
Suitable growing region	:	Hilly and coastal areas of Odisha

	Key traits	:	Spreading plant type with mostly purple vine and light purple emerging leaf, leaf shape triangular and petiole is green with purple spot at the leaf junction. Storage root round to ovate with white skin and cream flesh. Very good cooking quality, soft, mealy and very sweet, tolerant to sweet potato weevil, suitable for both *kharif* and *rabi* seasons.

9. Kalinga

Year of release	:	2004
Pedigree	:	Selection from open pollinated seed
Yield	:	17 t/ha
Duration	:	105-110 days
Suitable growing region	:	Odisha
Key traits	:	Spreading type with green vine and green with purple edged emerging leaf, leaves deeply lobed, moderate flowering. Storage root is round to elliptic with purple red skin and cream flesh, excellent cooking quality.

10. Sree Kanaka

Year of release	:	2004
Pedigree	:	Hybrid (S.187 × H.633)
Yield	:	10-15 t/ha
Duration	:	75-85 days
Suitable growing region	:	Kerala
Key traits	:	Compact with green vine and dark purple emerging leaf, leaf 3-5 lobed, very sparse flowering. Storage root cylindrical, skin colour cream with reddish yellow tinge and dark orange flesh, short duration variety with high carotene content of 8.4-10.6 mg/100g fresh weight.

11. Sree Arun

Year of release	:	2002
Pedigree	:	Seeding from recurrent selection of seeds of polycross
Yield	:	20-28 t/ha
Duration	:	90 days
Suitable growing region	:	Kerala (uplands)
Key traits	:	Spreading type, vine green with light brown emerging leaves, leaves cordate with green petiole, sparse flowering. Storage roots fusiform, short/spherical with very pale pink skin and cream flesh.

12. Sree Varun

Year of release	:	2002
Pedigree	:	Seedling selection of seeds from CIP, Peru
Yield	:	20-28 t/ha
Duration	:	90 days
Suitable growing region	:	Kerala (uplands)
Key traits	:	Spreading with green vine and slightly five lobed leaves, profuse flowering. Fusiform, short / spherical storage roots with cream skin and cream flesh.

13. Gouri

Year of release	:	1998
Pedigree	:	Hybrid (H-219 × H-42)
Yield	:	19 t/ha
Duration	:	110-120 days
Suitable growing region	:	Odisha
Key traits	:	Semi erect type with slightly purple vine and slightly purple emerging leaves, leaf simple with 5-6 lobes, profusely flowering nature. Storage root obovate to round elliptic with purple red and deep orange flesh, excellent cooking quality. A medium duration variety with carotene content of 4.5mg/100g fresh weight, can tolerate mid season moisture stress, suitable for *kharif* and *rabi* seasons.

14. Sankar

Year of release	:	1998
Pedigree	:	Hybrid (H-219 × S-73)
Yield	:	14 t/ha
Duration	:	120 days
Suitable growing region	:	Odisha
Key traits	:	Spreading type with green vine and green with purple edged emerging leaves, hastate leaf, petiole green with purple near leaf base, moderate flowering. Elliptical storage root with red skin and pale yellow flesh, medium duration variety with excellent cooking quality.

15. Sree Rethna

Year of release	:	1996
Pedigree	:	Selection from open pollinated progeny of S-13
Yield	:	20-22 t/ha
Duration	:	90-105 days
Suitable growing region	:	Kerala
Key traits	:	Spreading with light greenish brown vine and brown emerging leaf, light green shouldered leaves, profusely flowering type, storage root spherical with purple skin and orange flesh. Carotene content 1.92-2.10 mg/ 100g fresh weight, excellent cooking quality.

16. Sree Bhadra

Year of release	:	1996
Pedigree	:	Seedling selection of seeds introduced from Nigeria in 1984
Yield	:	20-22 t/ha
Duration	:	90 days
Suitable growing region	:	Kerala, Maharashtra, Bihar and Madhya Pradesh

	Key traits	:	Semi spreading with greenish brown vine and dark brown emerging leaves, leaves broad cordate, profusely flowering type. Storage root spherical with light pink skin and cream flesh, carotene content of 0.48-0.6 mg /100g fresh weight, excellent cooking quality, useful as a trap crop for root knot nematode (*Meloidogyne incognita*). Can tolerate soil salinity up to 16 dS /m

17. Sree Nandini

Year of release	:	1987
Pedigree	:	Selection from open pollinated progeny of S-32
Yield	:	20-25 t/ha
Duration	:	100-105 days
Suitable growing region	:	Kerala
Key traits	:	Spreading, green vine with emerging leaf light green in colour, leaf unifoliate with entire margin, moderate flowering, storage root fusiform with cream skin and yellow flesh. Tubers have excellent cooking quality and sweet, drought tolerant, suitable for paddy fallows as a catch crop.

18. Sree Vardhini

Year of release	:	1987
Pedigree	:	Selection from open pollinated progeny of S-13
Yield	:	20-25 t/ha
Duration	:	100-105 days
Suitable growing region	:	Kerala
Key traits	:	Semi spreading, green vine with pink tinge, emerging leaf light brown, leaf simple with 3-4 lobes, profusely flowering type. Storage root short, fusiform with purple skin and yellow flesh. Carotene content of 0.72 mg/100g fresh weight .

19. Varsha

Year of release	:	1983
Pedigree	:	Double cross hybrid (Acc.No.39 × Acc. No.3) × (Acc.No.1871 × Acc.No.1103)
Yield	:	17-22 t/ha
Duration	:	120 days
Suitable growing region	:	Konkan region of Maharashtra
Key traits	:	Semi spreading with dark green vine with simple 3-5 lobed leaves, shy flowering, tubers fusiform with reddish purple skin, light yellow flesh and drought tolerant.

20. H-42

Year of release	:	1971
Pedigree	:	Hybrid (Vella Damph × Triumph)
Yield	:	22-25 t/ha
Duration	:	120 days
Suitable growing region	:	Kerala, Tamil Nadu, Karnataka
Key traits	:	Semi spreading, vine greenish with pink tinge, emerging leaf light purple, unifoliate leaf with toothed margin, petiole greenish with purple tinge, profusely flowering, storage root fusiform with pink and cream flesh.

21. H-41

Year of release	:	1971
Pedigree	:	Hybrid (Norin × Indigenous cultivar)
Yield	:	20-25 t/ha
Duration	:	120 days
Suitable growing region	:	Kerala, Tamil Nadu, Karnataka
Key traits	:	Semi spreading, green vine with unifoliate leaf, profusely flowering, storage root fusiform with white flesh and excellent cooking quality.

Climate and soil

Climate

Areas with an average day temperature of more than 24°C and an average annual rainfall of 750 mm or more are suitable for its cultivation. Short day with low light intensity

promote root development, while excess rainfall and long photoperiod encourages vine growth and reduces tuber yield. Sweet potato require a day length of 11.5 hours or less to promote flowering, at 13.5 hours, flowering ceases, but yield does not appear to be affected.

Soil

Sweet potato perform well in well-drained, fertile, sandy loam soils having high organic matter content. The optimum pH range of the soil should be 5.2 to 6.7. Water logging is not good for its cultivation.

Quality planting material production

Vine cuttings, obtained from harvested plants or from nursery are used for field planting. Vines of 20-30 cm length with at least 3-4 nodes are found to be ideal as planting material. The cuttings obtained from the apical and middle portions of vines are preferable to get higher sprouting percentages and better tuber yields. The cuttings with intact leaves are stored under shade for two days before planting in the main field to promote better root initiation, early establishment and higher yield. If tubers are used, nursery is raised in two stages: primary nursery and secondary nursery for getting enough cuttings.

Preparation of nursery for the production of vines from sweet potato tubers

Primary nursery

The nursery is prepared about 3 months before planting in the main field. About 100 m^2 primary nursery area and 100 kg of medium sized weevil free seed tubers, each weighing 125-150 g are required for planting one hectare of land. The tubers are planted at 25 cm apart on ridges formed at a spacing of 60 cm. Urea need to be applied 15 days after planting @ 1.5 kg urea per 100 m^2 to ensure quick growth of vines and the nursery will be irrigated on every alternate day for the first 10 days and thrice a week thereafter. The vines are clipped off at a length of 20-30 cm after 40-45 days of planting, for replanting in the secondary nursery.

Secondary nursery

The vines obtained from the primary nursery are further multiplied in the secondary nursery of area 500 m^2, which produces enough planting material to plant one hectare of land. About 500 kg farmyard manure (FYM) or compost may be applied at the time of preparation of the nursery. The vines obtained from primary nursery are planted at a spacing of 20 cm on ridges formed 60 cm apart. Urea @ 1 kg per 100 m^2 will be applied in two split doses at 15 and 30 days after planting. After 45 days, vines are ready for planting in the main field.

Agro-techniques

Planting season

Sweet potato is grown as a rainfed crop utilizing the south–west monsoon during *kharif* (June-August) and as an irrigated crop utilizing the north-east monsoon during *rabi* (October-December) seasons in uplands or as a summer crop in low lands.

The ideal planting time of sweet potato in the different states of India is given in Table 3.

Table 3. Ideal time of planting sweet potato in different states of India

States/Regions	Time of planting
Bihar, West Bengal, Assam, NE states and Uttar Pradesh	Second fortnight of September to first fortnight of October
Bihar, Jharkhand	Middle of January to middle of February (irrigated)
Chhattisgarh, Madhya Pradesh and Chotanagpur plateau of Bihar	August- September
Diara land in Bihar and eastern Uttar Pradesh	November after recession of flood
Andhra Pradesh	August and November
Tamil Nadu	May- June (rainfed), September-October (irrigated)
Kerala	June-August (rainfed), October-December (irrigated)

Methods of planting and spacing

The different types of land preparation for planting practiced in sweet potato include, mound, ridge and furrow, bed and flat methods. Among the different methods, ridge and furrow followed by mound method is mostly practised which gives better yield. It is preferable to plant sweet potato on mounds in areas with poor drainage. When sweet potato is planted on mounds, a specific spacing of 80x75 cm is recommended and 3-6 vine cuttings per mound are planted (Fig. 1a). In sandy soils, mounds with shallow basin is preferred for retaining water. A spacing of 60x20 cm is recommended when planted on ridges to accommodate 83,000 plants in one hectare (Fig.1b). Ridges formed across the slope are recommended in sloppy areas to prevent soil erosion. The vines planted at 25-30 cm apart on ridges of height 20-25 cm made at 60-75 cm apart is recommended when the top soil depth is shallow. In the prepared land, the method of planting is horizontal/slant burial. When planted horizontally, only the middle portion of the vine with two to three nodes is buried in soil to a depth of 5-10 cm keeping both the ends exposed is the usual practice. Though slant burial favours marketable tuber yield, root girth is better in horizontal planting.

The main field should be completely open without any shade and tuberization will be affected if planted in shade. Varieties like ‘Samrat’ and ‘Sankar’ are suitable to grow under intercropping in coconut.

Fig.1a. Mound method of planting

Fig. 1b. Planting material, ridge method of planting

Nutrient management

The potential productivity of sweet potato under ideal conditions is 80-100 t/ ha, but the global average yield is 10.22 t / ha. In semi subsistence systems, the average yield is 4-6 t/ ha. This gap implies the potential for improving productivity by addressing the spatial and temporal variability of soil and plant characters. Among the different factors contributing to productivity, soil nutrients deserve special mention because of their substantial influence in sweet potato yield and the large gains that can be achieved by alleviating their deficiencies. The major soil factors contributing to yield limitations in sweet potato include, nutrient deficiencies, mineral toxicities, soil acidity and depletion of soil nutrients due to continuous cropping. Growing sweet potato without addition of manures and fertilizers causes soil sickness due to nutrient mining.

Nutrient uptake

For a tuber yield of 20 t /ha, the uptake of N, P and K is 123, 16 and 175 kg/ ha under a NPK recommendation @ 50:25:50 kg/ha. As regards to an NPK recommendation @ 75:50:75 kg/ha the N, P and K uptake was determined as 99 kg, 22 kg and 176 kg/ ha respectively. Sweet potato removes 6.15 kg N, 0.78 kg P and 8.75 kg K for the production of one ton of root.

Plant and soil sample collection for analysis

The third and second youngest fully expanded leaf (YFEL) at 42 days after planting were seen as the best reflectors for assessing the critical levels of P (0.41%) and K (3.15%) respectively and these leaves are considered as the index leaves for P and K analysis in laterite soils. The critical nutrient concentration (CNC) in the index leaf tissue which is the youngest fully expanded leaf at one month after planting under sand culture can be taken for comparison of nutrient contents obtained on analysis for delineating as deficient or sufficient with respect to major, secondary and micronutrients. The CNC of the index leaf is given in Table 4.

Table 4: Critical nutrient concentration in the index leaf tissues of sweet potato

Nutrient	CNC
N (%)	4.00
P(%)	0.22
K(%)	2.60
Ca (%)	0.76
Mg (%)	0.12
S (%)	0.34
B (ppm)	40.00
Cu (ppm)	4.50
Fe (ppm)	33.00
Mn (ppm)	19.00
Zn (ppm)	11.00

Soil samples are usually taken at the time of plot preparation from a depth of 0-20 cm. If regular sampling needs to be done during the experimental period, it can be taken from the interspaces of the mounds. The critical concentration of soil P and K was determined as 122.5 kg/ ha P_2O_5 and 125 kg/ ha K_2O in the high P laterite soils of Kerala.

Essential nutrients and deficiency symptoms

Nitrogen (N)

Sweet potato generally responds to small doses of N application. Excessive N application results in profuse leaf production at the expense of root yield. N deficiency is usually noticed in sandy soils and soils low in organic matter content.

Phosphorus (P)

Phosphorus deficiency and response to P application are most common in acid soils, especially in laterite and red soils, such as Oxisols, Ultisols, Inceptisols etc., which contain high levels of Fe and Al.

Potassium (K)

Potassium plays a major role in the translocation of photosynthates from the leaves to the roots and accelerates the process by contributing to the rapid cambial activity in the tuberous roots in which starch is stored. When K is applied, the activity of the enzyme, starch synthetase increases but when it is lacking, the enzyme activity becomes extremely low.

Secondary nutrients (Calcium: Ca, Magnesium: Mg and Sulphur: S)

Calcium plays a major role in the water regulation of the plant, while magnesium is a constituent of chlorophyll and is, therefore essential for photosynthesis. Sulphur is a basic component of various aminoacids and is required for protein synthesis. The deficiency of these nutrients is generally encountered in highly leached acid soils.

Micronutrients

Introduction of more refined and complex forms of fertilizers coupled with an increase in the intensity of cropping are bound to limit the yield of crops. Therefore, a timely and precise appraisal of micronutrient deficiencies is necessary to take prompt and appropriate remedial measures to realize best yields.

The major nutritional disorders manifested in sweet potato and their management measures are described below:

Phosphorus (P) deficiency

Symptoms:

- Purplish discolouration of older leaves.
- These discoloured leaves will turn yellowish and later dry and shed (Fig.2).

Fig. 2. P deficiency symptoms in sweet potato leaves

Management :

- Application of recommended dose of P or as per soil test data.

- Even in high P soils, basal application of P needs to be done if P deficiency symptoms in crops are manifested.
- In severe P deficiency, foliar application of 19:19:19 @ 0.5-1% can correct the symptom manifestation.

Potassium (K) deficiency

Symptoms:

- Marginal curling inward and drying of the older leaves followed by yellowing of the leaves and complete drying and death of the plant (Fig.3).

Fig. 3. K deficiency symptoms in sweet potato leaves

Management:

- Application of recommended dose of K or based on soil test data in two splits and if the soil is too deficient, the K rate can be increased to 25-50% more than the recommendation.
- After manifestation of the symptom, further expression can be prevented by foliar application of sulphate of potash (SOP) @0.5-1% at fortnightly intervals till the symptom disappears.

Calcium (Ca) deficiency

Symptoms :

- Cupping , crinkling and curling of the younger leaves followed by yellowing, drying and shedding of the leaves (Fig.4).

Fig. 4. Ca deficiency symptoms in sweet potato leaves

Management:

- Application of liming materials such as lime or dolomite @ 2 t / ha.
- After the occurrence of the symptom, foliar spray with 0.5% $CaNO_3$ at fortnightly intervals till new leaves without symptoms appear (Fig.4).

Boron (B) deficiency

Symptoms:

- Leathery appearance of the young tender leaves.
- Rosette appearance of the apical portion of the vines.
- Black dots on the tuber surface making them unsuitable for markets.
- Tubers seen cracked severely with the flesh becoming woody.

Fig.5. B deficiency symptoms in sweet potato tubers

Management:

- Liming the soil either with lime or dolomite (refer the lime/dolomite rate as per pH given under INM) 15 days prior to land preparation so as to raise the soil pH and increase the Ca content of the soil.
- Follow balanced application of FYM and NPK as per the recommended rate.
- Apply borax/solubor @ 5 kg/ha by mixing with sand or soil in the ridge/mound at the time of planting along with irrigation.
- After top dressing, solubor @ 5 kg/ ha mixed with sand/soil need to be applied in the soil at 50-60 DAP.
- Apply solubor 0.1% as foliar spray @ 650 litres/ha once at maximum vegetative growth stage (40-45 DAP) and again two times at tuber bulking stage (50-60DAP and 70-80DAP).
- After continuing this recommendation for three seasons, further soil and foliar application of B may be done based on the occurrence/non occurrence of the symptom and soil B status at that time.

- Care must be taken to strictly adhere to the maximum concentration of B for foliar application as 0.1-0.5 % depending upon the vegetative growth of the crop.
- In the Alfisols of Odisha, it is recommended to apply 1.5 kg boron (B) as borax ($Na_2B_4O_7.10H_2O$; 10.5%) @14 kg/ha at the time of planting.

Nutrient management approaches

The different nutrient management practices followed for sweet potato in the different parts of the country is described below:

a. Blanket recommendation

The common organic manure used is farmyard manure (FYM) @ 5 t/ha. N, P and K @ 50:25:50 kg/ha is followed for Kerala, whereas, it is FYM @ 4 t/ha along with N, P, K @75:50:75 kg/ha for Odisha. As regards to the method of application, full dose of P_2O_5 and K_2O and half dose of A needs to be given at the time of planting, and the remaining half dose of N at one month after planting along with first weeding and earthing up. Split application of N at planting and 30 days later is advantageous in moderating top growth during tuber development period to achieve good tuber yield. Delayed N application was unfavourable for tuber formation in sweet potato grown on sandy loam soils.

At the time of land preparation, apply FYM along with urea @ 55 kg or ammonium sulphate @ 125 kg, rock phosphate @ 125 kg and muriate of potash (MOP) @ 85 kg per hectare (250 cents) followed by top dressing with urea @ 55 kg or ammonium sulphate @ 125 kg along the side of the ridges/mounds, a month after planting in the case of the blanket recommendation followed in Kerala. Since di ammonium phosphate (DAP) is a common fertilizer used in almost all states of India, while applying the same as per the NPK recommendation @ 50:25:50 kg/ha, DAP @ 55 kg /ha along with 85 kg MOP at the time of planting and urea @87 kg/ha at one month after planting should be followed.

It is seen that, only 40-50 per cent of applied N in the form of urea is utilized by the plants and the rest is lost through leaching, volatilization and denitrification. Such low efficiency of utilization can be improved by modifying the urea to release N in a regulated fashion throughout the growing season. Different techniques of coating urea can improve nitrogen use efficiency in the Indian farming system.

Tri calcium phosphates like rock phosphates are equally effective to single super phosphate in direct effect, and superior in residual effect in acid soils like laterite soils. Rock phosphate maintained or slightly improved the availability of P in acid laterite soils even when it was skipped, confirming its superiority in residual effect as compared to single super phosphate. Available P in the soil was further enhanced when rock phosphate was applied along with mycorrhiza. Since sweet potato do not require very large quantities of phosphate for root development, a dose of 25-50 Kg/ha is considered optimum.

K fertilization is very effective in sweet potato as it increases the number of tubers and the ratio of large to small tubers.

Recommendation of N P K followed in the different states of India is given in Table 5.

Table 5. Nutrient recommendations for different states of India

States	FYM (t/ ha)	NPK (kg / ha)
Bihar, West Bengal and Assam	10	40-60: 40: 40-60
Andhra Pradesh	-	60: 60: 60
Karnataka	-	60: 60: 90
Kerala	5	50:25:50
Saline Entisols of Odisha	-	56:16:47
Saline Inceptisols of West Bengal	-	75:22:63
Saline Alfisols of Andhra Pradesh	-	56:16:47
Saline soils of Andaman islands	-	50:25:50

b. Integrated nutrient management (INM)

The INM practice in sweet potato involves conjoint application of organic manures, chemical fertilizers and biofertilizers.

In the laterite soils of Kerala (Ultisols), along with FYM and NPK recommendation as given in blanket recommendation, the secondary and micronutrient recommendation is as follows:

Liming: The soils of the major sweet potato growing tracts of India are laterite, sandy and alluvial in nature. Especially in the laterites and sandy soils, non tuberization and occurrence of nutritional disorders due to K, Ca and B are presently very common. Moreover, these soils are very deficient in these nutrients too. In order to enhance tuberization, liming of the soil to raise soil pH to 6-7 is found as a good practice. Hence in acid soils, lime application in sweet potato is very important as soil acidity limits tuberization and in slightly acidic-nuetral-alkaline soil, good tuberization was observed. In this regard, lime or dolomite is recommended for soils ranging in pH from 3.5 to 6.5 for better tuberization as when pH is 3.5, 4.0, 4.5, 5.0, 5.5, 6, 6.5, the rate of lime/ dolomite can be @ 8, 7, 6, 5, 4, 3, 2 t/ha respectively which can be applied at land preparation. The recommendation of secondary and micronutrients developed for the laterite soils (Ultisols) of Kerala as a component of the INM practice is as follows:

Application of magnesium, zinc and boron: Though magnesium deficiency disorders are not seriously encountered, if the available magnesium in the soil is below the critical level of 1cmol/kg (120 ppm), apply magnesium sulphate (commercially available) @ 80 kg/ha. In the case of zinc also, as a precaution, apply commercially available zinc sulphate @ 20 kg/ha, if the available zinc in the soil is below the critical level of 0.6 ppm. Unlike magnesium and zinc, boron deficiency disorders are very common in all

soil types of India. If the available boron in soil is below the critical level of 0.5 ppm, apply commercial grade borax or solubor @ 10 kg/ha.

If all these nutrients are needed as per soil test, give an interval of 5-10 days between applications and can be done 5-10 days after top dressing. If the soil test values of these nutrients are above the soil critical levels, above rates can be reduced to 50 or 25% based on soil test data as a maintenance dose. Based on soil test results or on the appearance of deficiency symptoms, it is recommended to apply 0.1-0.5 % solubor, 0.1% Zn EDTA and 0.5% magnesium sulphate independently as foliar spray. Three foliar sprays are recommended, one during peak vegetative growth stage (40-50 days after planting: DAP) and the other two at an interval of 10-15 days during the tuber bulking stage in the case of sweet potato with normal duration of 110-120 days. The soil application too is recommended while the foliar application is done. In the case of short duration varieties (85-100 days), the three foliar applications can be done as 30-40, 55-65 and 75-85 DAP respectively.

As regards to combined application of major nutrients *viz*., N, P, K along with micronutrients like zinc and boron, for enhancing tuber development and bulking, foliar application of ALL 19 (19:19:19) 1% mixed with Zn EDTA 1% together in 625 litres/ ha during the peak vegetative growth stage of the crop can be done. This is followed by application of potassium nitrate 1% mixed with 0.1% solubor together @ 625 litres/ha twice during the tuber bulking stage as mentioned earlier is recommended.

In the acid Alfisols, INM strategy comprised of the application of either FYM @ 4 t / ha or green manuring in situ with cowpea or application of neem cake @ 0.5 t/ha and NPK @ 75:50:75 kg/ha along with lime @ 0.5 t / ha and magnesium sulphate @ 25 kg/ ha. The optimum dose of zinc and magnesium for orange fleshed sweet potato in this soil is zinc sulphate and magnesium sulphate @ 20 and 30 kg/ ha respectively.

As regard to the use of biofertilizer component in INM, in sweet potato, integrated use of *Azospirillum* and AM fungi with N and P fertilizers @ 75% and 50% of the recommended dose respectively is recommended to maintain soil health and ensure high crop productivity. Application of the 2/3 recommended dose of N along with *Azospirillum* @ 2 kg/ha as vine dipping and *Azospirillum* @ 10 kg/ha as soil application is recommended for Tamil Nadu, Assam, Bihar, West Bengal and Kerala. In Andhra Pradesh, the dose of fertilizer N recommended is 1/3 of the N recommendation by integrating with the above biofertilizers. In the acid laterite soils of Kerala, *Enterobacter* sp. is recommended as a good biofertilizer microbe to substitute chemical fertilizer P up to 75%.

c. Soil test crop response (STCR) recommendation

Fertilizer adjustment equations for targeted yield in sweet potato with and without FYM according to STCR concept developed for the acid laterite soils of Kerala (Ultisols) is given below:

Targeted yield equation without FYM :

T- Targeted yield (t/ha)

FN	1.580 T - 0.7812 SN
FP_2O_5	0.300T - 0.0619 SP
FK_2O	1.700 T - 1.348SK

Targeted yield equation with FYM (5t/ha):

FN	1.580 T - 0.7812 SN -41.65 ON
FP_2O_5	0.300T - 0.0619 SP - 6.38 OP
FK_2O	1.700 T - 1.348SK - 14.71 OK

FN- Fertilizer N, FP_2O_5 - Fertilizer P_2O_5, FK_2O- Fertilizer K_2O, SN- Soil available N, SP - Soil available P, SK - Soil available K, ON - N supplied in soil through organic manure, OP - P supplied in soil through organic manure, OK - K supplied in soil through organic manure

Validation of STCR by ICAR- CTCRI in farmers' fields in Thiruvananthapuram district of Kerala for an yield target of 15 t /ha resulted in an yield of 14.67 t / ha over PoP (9.66 t / ha) recommendation and STCR registered the highest net income (Rs. 22,757/- per ha) and B: C ratio (2.07).

d. Site specific nutrient management (SSNM)

Site specific nutrient management (SSNM) is an approach of supplying plants with nutrients to optimally match their inherent spatial and temporal needs for supplemental nutrients. The SSNM approach aims to enable farmers to dynamically adjust their fertilizer use to optimally fill the deficit between the nutrient needs of a high yielding crop and the nutrient supply from naturally occurring indigenous sources such as soil, crop residues, organic inputs and irrigation water. It aims to apply nutrients at optimal rates and times to achieve high profit for farmers, with high efficiency of nutrient use by crops across spatial and temporal scales; thereby preventing leakage of excess nutrient to the environment.

The blanket fertilizer recommendations or their soil test-based adjustments do not take into account the climatic yield potential of different regions, cultivar characteristics, yield targets and nutrient interactions. The fertilizer adjustment equations based on targeted yield approach (STCR equations) cannot be extrapolated to another soil condition. Moreover, the nutrient interactions according to Liebig's law of minimum are not considered in earlier methodologies. The only alternative methodology to address above limitations and to bridge the yield gap is to develop more knowledge-intensive and computer simulation model-based site-specific nutrient management (SSNM) technologies that take into account both the spatial and temporal variability in soil and plant properties.

The results of SSNM studies showed that, to produce one ton tuber, 16:6:18 kg N, P, and K, respectively, would be needed with internal efficiencies of 61:167:57 kg tubers/ kg NPK uptake. The maximum accumulation and dilution (kg tuber/kg nutrient uptake) of N (40, 80), P (96, 272), and K (30, 85) are also derived as standard parameters in QUEFTS for optimum fertilizer recommendation of sweet potato in tropical and subtropical regions of India. The SSNM studies also developed the relationship between soil NPK supply and soil chemical properties for major sweet potato production regions of India. Calibration and subsequent validation of the model in sweet potato showed 15% yield increase in SSNM compared to present recommendation or farmers' practice. Table 6 gives the SSNM recommendations developed based on modified QUEFTS model. In soils with medium NPK fertility status, application of customized fertilizer formulation with the composition of 11:7:11:6:3:0.4:0.1 of N: P: K: Ca: Mg: Zn: B at the rate of 650 kg/ha is recommended for a target yield of 20 t/ha.

Table 6. SSNM recommendations for sweet potato 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	75	100	-	-	Below 10	50	60	-	-	Below 180	75	100	-	-
0.5 – 0.8	50	75	100	-	10-20	35	50	60	-	180-280	50	75	100	-
0.8 – 1.2	35	50	75	100	20-30	25	35	50	60	280-360	35	50	75	100
Above 1.2	25	35	50	75	Above 30	-	25	35	50	Above 360	25	35	50	75

***Sree Poshini (Mobile app for SSNM)*:** Considering the rapid spread of internet and mobile technology among Indian farmers, the ICAR-CTCRI recently launched a mobile app, Sree Poshini which is available for free download at Google Play store. Sree Poshini is a very simple mobile app, which helps the tuber crops farmers to calculate the fertilizer requirements of cassava and other tuber crops based on SSNM technology.

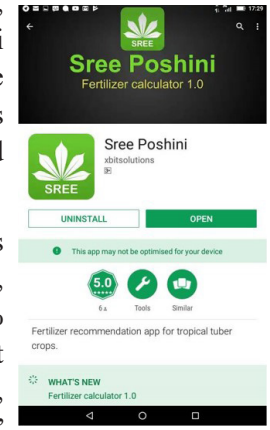


Fig. 6. Sree Poshini, a mobile app

Foliar liquid micronutrient formulations: ICAR-CTCRI has developed a microfood formulation containing zinc, copper, boron, iron and manganese at 2, 0.6, 0.2, 0.5 and 0.25% concentrations prepared based on crop requirements for sweet potato. This customized liquid micronutrient formulation, commercially available in the market as 'Micronol Sweet Potato' (Fig.7) may be applied as foliar spray @ 5 ml litre thrice on 15,

30 and 45 days after planting. One litre of the formulation in 200 litres of water is required for spraying in one acre.

Fig. 7. Multi micronutrient formulation commercialized for sweet potato

e. Organic farming

Organic farming entails an ecological production management system focusing on soil health, environmental protection as well as human health by largely excluding the use of synthetic chemicals and with the minimum use of off farm inputs. Since sweet potato removes considerable amount of nutrients, incorporation of organic manures at the time of planting is recommended to maintain soil fertility. Application of organic manures has significant impact on growth and tuber yield of sweet potato. Usually farmyard manure, cow dung compost or green manure is used as organic manures for sweet potato. The protocols to be followed in organic production are briefed below.

It is preferable to grow sweet potato variety, local or improved, that is having great demand in market. Use of pest-and disease-free healthy vine cuttings of orange-fleshed sweet potato variety, Bhu Sona (which contains 10-13 mg β-carotene/100 g fresh tuber) is recommended. Plant vine cuttings of 20-30 cm length from organically grown sweet potato.

Organic manures need to be applied based on N requirements. The total N requirement is calculated by considering N content in 5 t FYM + 50 kg fertilizer N. Nutrient content of organic manures should be analyzed before application. *Azospirillum, Azotobacter,* phosphorus solubilizing bacteria and *Trichoderma* combinations can be used as biofertilizers applied into the soil @ 5 kg/ha each. The different options in the use of commonly available manures for organic sweet potato production are as follows.

Trichoderma enriched FYM: FYM enriched with*Trichoderma* can be applied in organic farming. For enriching FYM with *Trichoderma*, one kg of *Trichoderma* formulation should be mixed with one ton of FYM and sprinkled with water, and then it is covered with polythene after heaping. The heap is to be turned once in 10 days and sprinkle with water. The enriched FYM can be used after a month. For FYM based organic farming, FYM @ 15 t/ha and *Trichoderma* @ 15 kg/ha is required.

Green leaf manuring/vermi compost: Alternative organic manures like green leaf manures or vermi compost can also be used in the place of FYM, depending on availability. Green leaves of *Gliricidia sepium* @ 17 t/ha can be incorporated 10-15 days before planting of sweet potato vines. Use of vermi compost @ 4 t/ha at the time of planting is also suggested for comparable tuber production.

Organic manures inoculated with biofertilizers: Inoculation of biofertilizers (*Azospirillum, Azotobacter,* phosphorus solubilizing bacteria and *Trichoderma*) with the commonly used organic manures will help to reduce the dose of FYM, green leaf manure and vermi compost to half. This will help to increase soil enzyme activities, microbial population and microbial biomass carbon. The organic manure source can be either FYM @7.5 t/ha or green leaf manure @ 8.5 t/ha or vermi compost @ 2 t/ha. These can be incorporated with biofertilizers @ 5 kg/ha.

It is advisable to follow neem-based plant protection measures in organic farming of sweet potato.

Water management

For proper sprouting and establishment of vines, it is appropriate to ensure sufficient moisture in the soil at the time of planting. Irrigation would generally increase the yield and improve the grade and quality of marketable tubers. Water stress during the critical growth stages will reduce tuber yield to 15-40%. In sweet potato, 3 irrigations spells tuber initiation, early tuber bulking and late tuber bulking stages were most favourable for higher number of tubers per plant, tuber bulking rate and dry matter content resulting in highest tuber yield. Tuber yield and water use efficiency of sweet potato irrigated at 0.7 atmospheric tension were higher than when irrigated at 0.35 atmospheric tension or at an interval of one month or without irrigation. Quantity of irrigation water is decided by the local weather and soil conditions and stage of the crop.

A light irrigation after planting to maintain sufficient moisture gives proper establishment of the crop. When sufficient soil moisture is not available, through rainfall supplementary irrigation need to be provided on alternate days initially for the first fortnight of planting and thereafter once in 7-10 days. A total of 12-15 irrigations are required during the entire crop period. In Kerala, sweet potato is cultivated in summer rice fallow using residual moisture and supplementary irrigation. The total water requirement of sweet potato for a crop season is worked out as 240-270 mm and the water productivity ranged from 9.0 – 9.5 kg/m^3. When grown in summer, the water requirement for one cent (for 333 plants) is calculated as 150-200 litres daily. Approximately, 300-500 ml of water is required per plant per day during the peak vegetative growth during summer months in Kerala. This can be followed till the tuber bulking stage. There after the irrigation can be reduced to 50-60% and can be stopped prior to 2-3 weeks to harvesting.

Providing irrigation at full rate of cumulative pan evaporation (CPE) during the tuber initiation phase (10-30 DAP) can enhance the growth parameters of sweet potato. The best IW/CPE ratio for maximum yield was determined as 0.8. Drip irrigation at the rate of 100% cumulative pan evaporation (CPE) gives maximum tuber yield in sweet potato. At Vellayani, Thiruvananthapuram, higher tuber yield was obtained at an IW/

CPE ratio of 0.75. At CTCRI, Thiruvananthapuram, enhanced growth parameters was observed with irrigation at full rate of cumulative pan evaporation (CPE) during the tuber initiation phase (10-30 DAP). At Chalakkudi, Kerala, irrigation at IW/CPE ratio of 1.2 with 50 mm water during dry months profoundly influenced the growth, tuber yield and net income compared to irrigation at an IW/CPE ratio of 0.8 and 0.4. At Bhubaneswar, an IW/CPE ratio of 1.0 was found to be ideal for maximum tuber yield. For dry zone of Telengana, during rabi season, 4-5 irrigations resulted in higher yields.

Weed management

Sweet potato vines cover the soil surface quickly and suppress most of the weeds. However yield loss due to weeds occurs in sweet potato. About 20% reduction in tuber yield was observed due to weed infestation in the early stages of growth. Hence, weeding is necessary, particularly in the early stages of growth, which improves the physical condition of the soil also. The critical period of weed competition starts before 14 days after planting, possibly as early as 7 DAP and continued up to 56 DAP. Hand weeding is effective at initial stages (before 15 DAP) Weed infestation at later stages, it adversely affects the tuber initiation and tuber bulking due to mechanical root disturbance. Pre-emergence application of oxyflourfen / pendimethalin @ 2.5 kg/ha effectively control weeds in sweet potato. Necessary care is needed while applying the chemical herbicides in sweet potato. Avoid direct spraying on the leaf surface as it may cause phytotoxicity. It is better to mix the pre emergence herbicides with sand/soil and apply uniformly in the field. Mulching with paddy straw @ 5-6 t/ha is the best organic means of weed management, where paddy straw is abundantly available.

Cropping systems

Sweet potato has been found to grow under different cropping sequences in eastern and southern regions of India. In Kerala, sequential cropping of paddy – paddy - sweet potato and paddy -sweet potato - fallow are common. A suitable cropping pattern of maize - sweet potato - wheat and moong / maize - sweet potato-onion has been suggested for Bihar. In Tamil Nadu, sweet potato is followed by a cereal crop. The common rotation followed in Odisha is maize - sweet potato - fallow and rice - sweet potato - fallow and in West Bengal, it is moong – taro - sweet potato. In Andhra Pradesh, sweet potato follows maize and is succeeded by vegetable crops. In Chhattisgarh / Uttar Pradesh / Maharashtra, vegetable cowpea - sweet potato is the common sequence. Sweet potato + pigeon pea (3:3 ratio) in 1.8 meter width strip of each component crop is recommended for hill and plateau regions under rainfed conditions. This system of intercropping registered significantly higher tuber equivalent yield and income in addition to enriching the soil with organic carbon and nitrogen contributed through pigeon pea.

Integrated farming system (IFS) involving sweet potato

IFS involving tuber crops like cassava, sweet potato, elephant foot yam, greater yam, yam bean and *Colocasia* along with rice, maize and vegetables in one hectare area produced 9468 kg rice equivalent yield, gross returns of Rs. 1,89,363/- and net returns of Rs 11,575/- whereas, rice alone produced 2800 kg and net returns of Rs 28,250/- from one hectare. In addition, this system generated 115 man days additional employment which was spread throughout the year.

e-crop based smart farming

e-Crop is an IoT device developed by ICAR-CTCRI for smart farming. This system simulates growth of any crop real-time, in response to the weather and soil parameter conditions and generates agro advisory to reduce yield gap. This advisory is sent to farmer's mobile as SMS. e-Crop based smart farming (e-CBSF) is a cost effective farming practice standardized for reducing yield gap and attain potential yield under the given weather conditions. Sweet potato growth simulation model SPOTCOMS, which is working at the back end of e-CBSF, generates advisory on the quantity of N, P and K fertilizers as well as water, which are to be applied at different time intervals on daily and 10 days or in one dose for the entire period left in its duration, so that crop will be able to attain potential yield. By following advisories, received in the mobile as SMS, the yield gap gets reduced to about 5% of the potential yield and yield increase of about 150-200% over conventional practice is recorded in the field. Requirement of N and K fertilizers for achieving this yield increase has been substantially low to the tune of about 50% of the conventional practice. Field validation of the efficacy of the e-CBSF (Fig. 8) technology for irrigation and fertilizer application in sweet potato, showed that, this system is much better in terms of water productivity and require much less water to get higher yield.

Fig.8. e-crop based smart farming in sweet potato

Pest management

Sweet potato weevil (*Cylas formicarius* Fabricius)

Symptoms:

Sweet potato weevil is the most important pest which causes damage both in the field and in storage. All stages of the pest can be found throughout the year if suitable hosts are available. On an average, 20-55% tuber loss occurs and yield loss may go up to 100% in severe cases. The damage to tubers can be seen on harvesting. The major form of damage is mining of the tubers by larvae. The infested tuber is often riddled with cavities, spongy in appearance, and dark in colour. Even low levels of feeding induce a chemical reaction that imparts a bitter taste and terpene odour to the tubers. Larvae also mine the vine of the plant, causing it to darken, crack, or collapse (Fig.9a). The damage by adult is less severe than by larvae. It may feed on the tubers, creating numerous small holes (Fig.9b). Adult (Fig.9c) feeding on the foliage is not much significant.

Fig. 9 a. Weevil attack in vine

b. Weevil attack in tuber

c. Adult weevil

Management:

- Careful ridging and regular hoeing .
- Regular irrigation to prevent the soil from cracking .
- Do not leave damaged crops in the field, that may re grow in the field and become a source of infestation.
- Remove weeds belonging to the *Ipomoea* genus like *I. triloba*, *I. palmata* over a distance of at least 150 m around the field.
- Plastic mulches and rice straw mulching reduce weevil damage.
- Dip the planting material in 0.02% chlorpyriphos (20 EC) (1 ml/ litre water) for 10 minutes before planting.
- Set pheromone traps @ 10 per hectare (Rentokil PCI provides pheromone traps @ Rs. 25 per piece of bait).
- Foliar spray of imidacloprid 17.8 SL @ 0.6 ml/ litre from one MAP (month after planting) at fortnightly intervals.

- Harvest the crop at the correct harvest stage without delay (exactly at the maturity stage of the crop).

Spotted tortoise beetle *(Aspidomorpha miliaris* Fabricius)

Both adults (Fig.10a) and larvae eat leaving large round holes in the leaves (Fig.10b).

Symptoms:

Attacks are sometimes so severe that, it may completely skeletonize the leaves and remove the peel of the vines.


Fig. 10 a. Spotted tortoise beetle b. Foliar symptom of beetle attack

Management:

- Weed control can manage the pest to a great extent.
- Spray neem oil or the biopesticide *Nanma* @ 1% (10 ml/ litre of water).

Sweet potato vine borer (*Omphisa anastomosalis* Guenee)

It is a serious emerging pest of sweet potato, which reduced the crop yield substantially for the past few years in several parts of India.

Symptoms:

Larvae (Fig. 11) attack the collar region of the vines, bore holes become visible and they form tunnels inside the vines. Severe attack cause withering and wilting/drying of the plants.

Fig. 11. Sweet potato vine borer larvae

Management:

- Spray and drench using thiamethoxam 25 WG @ 1 g/ litre or imidacloprid 17.8 SL @ 1 ml/ litre in the collar region of the plant and in the soil at fortnightly intervals.

Sweet potato leaf miner (*Bedellia somnulentella* Zeller)

It is a newly emerging pest in India, which cause heavy infestation in recent years.

Symptoms:

They attack both the upper and lower surfaces of the leaves. Since the leaves are completely eaten away, leaves become transparent and on an average, it causes 30 % leaf damage (Fig.12).

Fig. 12. Sweet potato leaf miner attack on leaves

Management:

- Clean cultivation and timely weeding to reduce the pest pupation in the soil.
- Plough the field and rake the soil around the vines to kill the pupae.
- Mulch with plastic sheets to avoid pupation in soil around the vines.
- When there is heavy infestation, apply spinosad 45% SC @ 0.3 ml/ litre at fortnightly intervals.
- Drench the collar region of vines with imidacloprid 17.8 SL (0.5 ml/ litre) at fortnightly intervals.

Convolvulus hawk moth (*Agrius convolvuli* Linnaeus)

Symptoms:

The larvae feed on the leaf blades, causing irregular holes, and may eat the entire blade, leaving only the petiole. Yield losses can occur due to this pest, if heavy defoliation occurs at early crop growth stage. A large caterpillar (Fig.13) can defoliate a plant and a large population of late instar larvae can defoliate a field overnight.

Fig. 13. Caterpillar of *Convolvulus* hawk moth

Management:

- Hand pick and destroy the pest.
- Spray emamectin benzoate 5G (0.25 g/ litre) or lamda cyhalothrin 5 EC (1 ml/ litre), only if the infestation is severe.

Rats

Commonly seen rats in tuber crop ecosystem are the greater Bandicoot rats: *Bandicota indica* Bechstein (Fig.14a) and the lesser Bandicoot rat :*Bandicota bengalensis* Gray (Fig.14b).

Fig. 14 a. Greater bandicoot rat b. Lesser bandicoot rat

The greater Bandicoot rat is the largest domestic rat which is also seen in the field. They can be considered as both domestic and field rats. Fur is coarse and tail length is almost equal to the body length. Body weight ranges from 750 to 1000 g. It damages all tuber crops.

The lesser bandicoot rat is a short tailed mole rat and tail length is only 70% of the body length. Fur is short and coarse and it is seen in areas where tuber crops are cultivated. Average yield loss caused by rodents in tubers is about 10-25%.

Management:

- Field sanitation.
- Use traps like automatic traps, glues, pot traps, snap traps and kerosene tin trap.

- Live burrow fumigation with aluminium phosphide (1 tablet / m^3).
- Poison baiting using zinc phosphide (2%).

Wild boar (*Sus scrofa* Linnaeus)

They are one of the biggest threats in tuber crops cultivation and can destroy hectares of crop area after destroying and eating away the tubers after uprooting. The wild boar (Fig.15) has a long history of association with humans, having been the ancestor of most domestic pig breeds and a big game animal for millennia. Boars have also re hybridized in recent decades with feral pigs. These boar pig hybrids have become a serious wild animal pest. They are mostly active at night time.

Fig. 15. Wild boar

Management

- Physical barriers like barbed wire fencing and galvanized iron fencing.
- Electric fencing (12 volt).
- Fencing using fishing net (4 feet high).
- Producing sound using crackers at uniform intervals with the help of automatic cracker station.
- Using olfactory repellents like borep developed by Kerala Agricultural University at 3-4 week intervals @ 2 kg/acre.
- Use of chemicals / materials with strong odours like rotten fish / egg as repellents which can confuse the olfactory capacity of these animals.

Disease management

Sweet potato feathery mottle disease (SPFMV)

Sweet potato feathery mottle disease is a major disease in India. The virus is capable of causing major crop losses of 50 - 80% especially when it occurs along with other sweet potato viruses.

Symptoms:

Leaf symptoms are generally mild and transient. Different types of symptoms were seen

in different cultivars which included, ring spot of pink colour with green or chlorotic centre, feathering, chlorotic specks, mosaic and puckering (Fig.16). The symptoms are seen more prominently in broad leaved cultivars and best during the active growth period (45-60 days after planting). Symptoms are more prominent on lower leaves.

Fig. 16. Different kinds of sweet potato feathery mottle symptoms

Management:

- Select planting material (vine) from healthy plants which are free from SPFMV infection.
- Grow resistant varieties like Sree Nandini and Sree Vardhini.
- Use vines obtained from meristem derived virus free plants.
- Rogue the field infected plants and follow sanitary measures very strictly.

Sweet potato leaf curl virus (SPLCV)

The sweet potato leaf curl virus (SPLCV) has great impact on global sweet potato production though it is not a serious problem in India at present. Since it is a whitefly transmitted begomovirus, it may be a threat to sweet potato in future.

Symptoms:

Leaf thickening, cupping, curling of leaves and yellow netting are the common symptoms (Fig.17). The virus is spread through planting materials, tubers/vines and white fly (*Bemisia tabaci*).

Management:

- Select planting material (vine) from healthy plants which are free from SPLCV infection.

Fig. 17 .Sweet potato leaves showing leaf curl symptom

Chlorotic leaf distortion (CLD) (*Fusarium denticulatum*)

The disease has no effect on yield of storage roots regardless of the severity of the disease.

Symptoms:

Leaves nearest to the vine tips (1-2 youngest leaves) develop a bright general chlorosis and are often twisted or distorted. White waxy substances (mycelia and conidia of the pathogen) are found on the upper surface of the young leaves which are unfolded (Fig.18). As the leaves mature, they regain normal green colour with only diffused chlorosis. However, the newly emerged leaves may continue to show chlorosis.

The fungus primarily colonizes the surface of the growing vine tip without invading the plant. Mycelia are present on apical meristems and between halves of developing leaves that have not yet opened. Once the leaves open and expose the fungal mycelia, the mycelia appear to stop growing. As a result, individual leaves appear to recover as they mature.

Fig. 18. Leaves showing chlorotic leaf distortion

Management:

- Control measures are considered not necessary, since CLD has no effect on tuber yield.

Black rot (*Ceratocystis fimbriata*)

Tiny, slightly depressed spots appear on the tubers. The colour of the spots changes from brown to greenish black on advancement of the disease (Fig. 19). The spots coalesce and spread to a major portion of the tuber and make the cooked roots taste bitter. The pathogen mainly enters the tubers through wounds caused during harvest or transport. Even a trace of infection in the tubers can lead to rapid spread in storage and can cause great loss to farmers.

Fig. 19 .Sweet potato tuber showing black rot

Management

- Crop rotation with nonhost crops and proper field sanitation.
- Use healthy planting material.
- Proper curing of tubers at 30-35^0 C and 85-95% relative humidity for 5-10 days immediately after harvest.
- Careful handling of tubers to minimize the wounds.
- Application of postharvest fungicides.
- Fumigate storage structures before storing the tubers.

Harvesting and yield

The exact duration of the crop varies according to cultivar and the environmental conditions under which it is grown. The normal duration of sweet potato is 100-110 days, but there are short duration varieties with 85-95 days duration and long duration can be harvested up to 120 days. In north India, sweet potato takes about 5-6 months for maturity, while it matures within 4 months in the South. The yield will increase if the crop remains in the ground for longer periods, but the tubers become less palatable and weevil damage and rots become more noticeable with age. The maturity of tubers can be determined by cutting fresh tubers. The cut surface of the immature tubers gives a dark greenish colour, while in mature tubers, the cut ends dry clearly. Single harvesting and double harvesting (progressive harvesting) are practiced in sweet potato. Double harvesting can be done between 90 and 150 days at intervals of 15-60 days for higher tuber yield, when compared to single harvesting at 150 days, especially under north Bihar conditions. Light irrigation 2-3 days before harvesting of tubers make easier digging. Early cultivars can be harvested at 90-105 days after planting, whereas, medium and late maturing cultivars at 110 and 120 days after planting, respectively. Remove the vines and dig out the tubers without making injury in the tubers (Fig. 20). After harvest, tubers must be spread in partial shade for 5-6 days for proper healing and curing and then can be stored in well ventilated rooms.

Yield of sweet potato tubers ranges from 14 to 28 t/ha depending on the varieties and cultural practices adopted. The average yield of short duration varieties ranges from 10-28 t/ha whereas the yield of normal and long duration varieties is in the range of 17-25 t/ha .

Fig. 20. Harvesting and tuber yield in sweet potato

Pre and post harvest machinery

Mobile starch extraction plant

The mobile starch extraction plant can be used for isolation of starch from freshly harvested tubers (Fig. 21). The major components of the machine are hopper, crushing cylinder with nail punched protrusions rotating inside the crushing chamber, sieving tray to remove the fibrous materials, stainless steel/plastic tanks to collect the starch suspension, tuber storage chamber, handle and wheels for easy transportation from place to place. Water input can be controlled through a water pipe with holes fixed inside the hopper and sieving through a shower attachment connected to the water line. The recovery of starch by using this machine is 75.1% for sweet potato with the crushing capacity of 135 kg/h.

Fig. 21. Mobile starch extraction plant

Processing and value addition

ICAR-CTCRI has developed several value added food products from sweet potato which included vacuum fried chips, bakery products, functional pasta and noodles, jam/jelly, vine, and ready-to-use food mixes. Sweet potato flour can be used in the preparation of composite flours mixed with wheat flour and protein sources, which can be utilized in the development of various food products.

Vacuum fried chips

Vacuum fried chips (Fig. 22) made from orange and purple fleshed sweet potato tubers are low in fat content and high in bioactive compounds. The chips prepared with the

Fig. 22. Vacuum fried sweet potato chips

orange fleshed variety, Bhu Sona contains about 6.81 mg/ 100g of β-carotene. The anthocyanin content in the vacuum fried chips prepared from Bhu Krishna, the purple fleshed variety, was 57.44 mg/100g.

Bakery products

The major bakery products developed form sweet potato included, cookies, bread, cakes and muffins. Protein and fiber enriched cookies developed from orange and purple fleshed sweet potato are rich in bio-functional components such as total phenols, total flavonoids, total carotenoids and anthocyanins. Bread and muffins are prepared from orange fleshed sweet potato (Fig.23). β-carotene rich cake prepared with 80% orange fleshed sweet potato flour (variety Bhu Sona) and 20% refined wheat flour contains about 6.3 mg/100g of β-carotene. The anthocyanin enriched cake made from 70% purple fleshed sweet potato flour (var. Bhu Krishna) and 30% refined wheat flour has a total anthocyanin content of 39 mg/100g. Protein enriched sweet potato nutribars are good source of essential nutrients and can be used as a snack or breakfast item.

Fig.23. Sweet potato based bakery products

Functional pasta and noodles

Sweet potato flour based functional pasta and spaghetti have been developed by enrichment with proteins, natural pigments, and dietary fibres. Process was optimized

for producing sweet potato pasta enriched with protein from low cost sources such as green peas, Bengal gram flour and casein (Fig.24). The protein content in the pasta varied from 7.5 to 15.1%. Pasta is also prepared from sweet potato-pseudo millet based composite flour (Fig.25). The flours used are sweet potato flour (55%), millet flour (15%), refined wheat flour (30%) and starch (5%) along with quinoa and buck wheat flour.

Fig.24. Sweet potato based composite flour pasta with low cost protein sources
(a) green peas (b) Bengal gram and (c) caseine

Fig. 25. Pasta from sweet potato-pseudo millet based composite flour

Antioxidant rich functional noodles are developed from sweet potato using antioxidants such as β-carotene, anthocyanin, betanin or curcumin either alone or in combination (Fig.26).

Fig.26. Betanin and anthocyanin enriched noodles

Functional spaghetti enriched with commercial dietary fibers such as NUTRIOSE and guar gum are rich in dietary fibers with high level of residual undigested starch, which makes them ideal foods for diabetic and obese people (Fig.27).

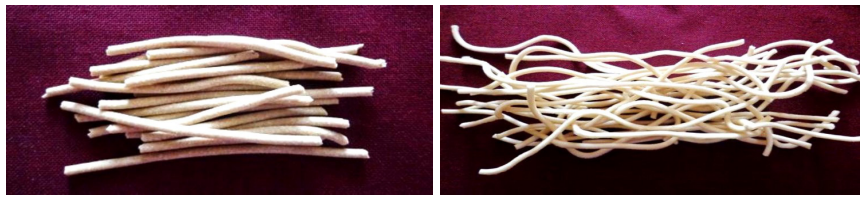


Fig.27. Dietary fibre enriched spaghetti and noodles

High protein starch noodles have also been prepared from sweet potato by fortification with different proteins which included whey protein concentrate, Bengal gram, green gram and black gram flours (Fig.28).The protein content in the products is in the range of 12 - 17%.

Fig.28. Whey protein and Bengal gram fortified noodles

Ready-to-use food mixes

Ready-to-use weaning food mixes have been developed from different combinations of sweet potato flour (20-30%), arrowroot flour (5-15%), chuda powder (20%), malted ragi flour (20%), rice flour (10%), sugar (6%), skimmed milk powder (8%) and starch (1%). The food mixes are rich in protein, minerals and fibre contents. Ready-to-use laddu mix contains different combinations of sweet potato flour (25-75gm), Bengal gram flour (25-75gm), sugar (20gm) and cardamom extract (1.5gm) per 100 g of the mix. The ready-to-use paratha mix contains sweet potato flour (50%), millet flour (15%), multigrain flour (30%) and dried spices (5%) and is a good source of micronutrients and protein (Fig. 29).

Fig.29. Ready-to-use laddu mix, weaning food mix and paratha mix

Anthocyanin rich nutri-jelly prepared using the extract of purple fleshed sweet potato variety Bhu Krishna contains 28.4% moisture which has a total soluble sugar (TSS) content of 67.51° Brix, 0.50% titratable acidity and 54.11 mg/100g anthocyanin content (Fig.30). The β-carotene rich nutri-jelly has a moisture content of 27.3%, TSS of 67.53°Brix, titratable acidity of 0.53% with a β-carotene content of 7.20 mg/100g. The nutri-jelly has good storage stability at ambient and refrigerated temperatures up to 90 days.

Fig.30. Nutrijelly and sauce from biofortifed sweet potato

Fermented food products

Lacto-juice prepared by the lactic acid fermentation of β-carotene-rich sweet potato has high nutritive value, vitamins and minerals which are beneficial to human health. The lacto-juice has beneficial probiotics properties of lactic acid bacteria and enriched with phenolics and β-carotene, which is considered as an antioxidant and anticancer compound and a precursor of vitamin A. There was no physiological and microbiological deterioration of lacto-juice for 30 days. The roots of orange flesh sweet potato variety, Bhu Sona have been pickled by lactic fermentation by brining the cut and blanched roots in 8-10% brine solution and subsequently inoculating with a strain of *Lactobacillus plantarum* (MTCC 1407) for 28 days. The lacto-pickle has a pH of 2.9-3.0, lactic acid concentration of 2.6-3.2g /kg and β-carotene content in the range of 169-176 mg/kg.

Value added industrial products

Sweet potato wine

A red wine with high content of anthocyanins (55.09 mg/mL) has been produced from purple fleshed sweet potato roots. The wine has the following proximate composition: TSS- 2.25º Brix; starch-0.15g/100 mL; total sugar-1.35g/100mL; Tartaric acid-1.34 g tartaric acid/100 mL; phenol- 0.36 g as caffeic acid equivalent/100 mL; tannin- 0.64 mg/100mL; lactic acid-1.14 mg/100mL; ethanol-9.33%(v/v); pH-3.61. The DPPH radical scavenging activity of the wine is 58.95% at a dose of 250 µg/mL.

Encapsulated anthocyanins

Anthocyanins, extracted and purified from purple fleshed sweet potato tubers and purple leaves, and encapsulated by spray drying with maltodextrin is a natural food colourant

with the added advantage of antioxidant properties (Fig.31). It can also be used in developing capsules as anthocyanin supplements.

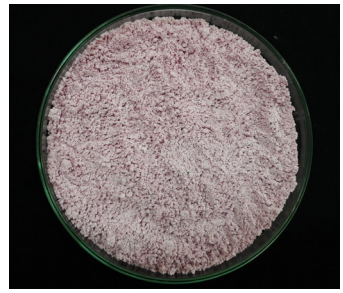


Fig.31. Encapsulated sweet potato anthocyanins

Sweet potato starch and modified starch

Sweet potato starch is extracted from the roots after peeling, crushing and removal of fibre by filtration and subsequent settling of the starch milk. The starch can be used in the preparation of glass noodles. Modified starches *viz*., heat-moisture treated and annealed starches have been prepared from sweet potato starch by physical modification techniques. Due to the many advantageous properties such as low set back viscosity, decrease in granular swelling and amylose leaching, and increase in heat and shear stability, annealed starch can be utilized in the canned and frozen food industries and for noodle manufacture. Heat-moisture treated sweet potato starch has reduced swelling power and paste clarity but enhanced aqueous solubility and paste stability which make them suitable as an ingredient in different food products.

Sweet potato resistant starch

Sweet potato starch can also be used as a thickener in various food products. ICAR-CTCRI has developed a process for the production of resistant starch *viz*., RS4 and RS5 type from sweet potato starch by chemical modification and complexation with fatty acid, respectively. Resistant starch (RS) is the portion of starch, which is not digested by enzymes in the intestine, but undergoes fermentation upon reaching the large intestine. The RS is considered as a dietary fibre and it facilitates the growth of microbiota and production of short chain fatty acids which are essential for colon health. Resistant starch (RS4) has been synthesized by octenyl succinylation of sweet potato starch which resulted in significant enhancement in RS, from the native starch content of 3.3% to 24.8-37.1% for the RS4 enriched starch with a reduction in estimated glyceamic index from 86.3 to 63.1-66.3%. Because of the increased levels of RS coupled with better encapsulating and emulsifying properties, these can be potentially used for encapsulation of bioactive materials and as low-calorie functional food ingredient.

Economics and marketing

Economics

In India, sweet potato is grown in an area of 1,06,000 hectares with a production of 11,21,000 tonnes of tubers. The average market price is Rs. 14/- per kg and the average market value is Rs. 15,694 million rupees. The employment generated for cultivating one hectare area of sweet potato is 160 man days and hence the total employment generated is 16.96 million man days.

As regards to the cost of cultivation taking into account around 83,000 plants in one hectare, it will be ranging from Rs. 80,000-1.00 lakh and the gross income generated by taking the average market price is around Rs. 1.00-1.5 lakhs per hectare.

Utilization pattern

Out of the total production of sweet potato, 1.1 million tonnes accounting to 98.2%, 0.01 million tonnes accounting to 1% and 0.009 million tones accounting to 0.84 % are used in food, feed, and for industrial purposes respectively.

Marketing

Sweet potato tubers are sold by farmers and aggregators in the Agricultural Produce Marketing Committee (APMC) and mandis, where commission agents / traders play an important role in channelizing the produces between the buyers and the sellers. In APMC's and mandis, tubers were auctioned to traders (wholesalers and retailers) which were transported to wholesale markets located in different cities in India for retailing.

Conclusion

Globally, among the various food crops, sweet potato ranks seventh after wheat, rice, maize, potato, barely and cassava. The traditional perspective about sweet potato was as a nutrient intensive food capable of meeting the energy and micronutrient requirement of the consumers. But presently, identification and popularization of biofortified varieties changed sweet potato to the status of a super food. This is primarily because of the unique phytochemicals especially antioxidants contained in it, which aid in imparting positive influence in all human organs from skin to brain. Scaling up of the biofortified varieties both orange and purple fleshed could augment for the eradication of malnutrition especially due to vitamin A deficiency in most of the developing countries through many global programmes like Harvest Plus and Sweet Potato for Profit and Health Initiative (SPHI). Recent research innovation by developing strategic planning tools like 'Sweet Potato Biofortification Priority Index' (SPBPI) helped in identifying high priority states for implementing field intervention of biofortified varieties. The 'Rainbow Diet Campaign' in progress in the high priority states of India like Mizoram, Meghalaya and Arunachal Pradesh will be a great thrust in making good impact of the

biofortified varieties among the low income tribal folks of the country especially in NEH states.

Considering the enormous potential of both tubers and leaves as a natural green food in supporting a healthy human immune system, it is imperative to widen the spectrum of awareness about this extremely powerful healthy crop to its end users for cultivation, consumption and value addition. This technical bulletin is a good compilation of the varieties and technologies developed for this crop by ICAR, SAU's and AICRP centres during the last six decades which are of very practical significance to the stake holders. Since the diffusion of technologies are one of the critical factors for large scale production and processing of this crop to achieve better livelihood security, building consumers' and producers' awareness of the nutritional benefits of the crop is the need of the hour. In this regard, the stakeholders must have access to improved varieties especially the biofortified ones. They must be imparted with knowledge on diversified uses of the tubers and leaves. Policy issues too might be favourable to open up new avenues for expanding market opportunities for sweet potato growers. It is expected that, this publication definitely must be a valuable information resource to those who are venturing to exploit the hidden potentials of the crop in making 'sweet potato for a sweet future'.

Sweet Potato for Food, Health, Wealth and Prosperity



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