

# Diversification, Propagation and Value Chain Issues in Underutilized Root and Tuber Crops

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## Abstract

Different ecological belts of Nepal are endowed with different types of climates due to its geographical locations and physiography which is favourable for agricultural production, especially vegetable crops including root and tuber (RandT) crops. Most of the important RandT crops of the world can be grown in Nepal and are the engine of growth for rural economy and poverty alleviation. RandT crops possess a huge genetic diversity at variety and landrace levels in Nepal. There are more than 30 edible and non-edible underutilized RandT crops reported in the world and among them, taro, yam, cassava, elephant foot yam, ground apple and sweet potato are the major cultivated RandT crops in Nepal. Despite the suitable climate, comparative advantages and great contribution in food security the growth of domestic production and its value chain development has remained slow in the past. Research work on root and tuber crop is inadequate and extension programme is almost lacking. RandT crops are mostly perennial crops but they are also cultivated as an annual crop as they become ready to harvest in 8-10 months. Suitable and productive varieties can be developed and expanded through the propagation of these crops by collection, conservation and promotion of RandT crops which ultimately help to improve the food security and nutrition.

**Keywords:** Climate, Conservation, Food security, Nutrition, Varieties

## Introduction

Nepal has favourable agro ecological diversity for agricultural production, especially in the vegetable sector including Root and Tuber Vegetable Crops. Different ecological belts are endowed with different types of climates due to its geographical locations and physiography. Most of the important Root and Tuber Vegetable Crops of the world can be grown in Nepal. The Agriculture Development Strategy (ADS, 2015) has recognized high value horticultural crops including Root and Tuber Vegetable Crops as engine of growth for rural economy and poverty alleviation. Plants yielding starchy roots, tubers, rhizomes, corms and stems are defined as Root and Tuber (RandT) crops (Scott *et al.*, 2000). Root crops should not be confused with root vegetables like radish, turnip, carrot and beetroot. Major Root and Tuber Crops including yams are categorized as tuber crops, taro and cocoyam are derived from corms/underground stems and swollen hypocotyls, and cassava and sweet potatoes are storage roots. RandT crops in Nepal are mainly used for human food but very little in processed form either for human consumption or animal feed. Since industries for manufacturing starch, alcohol and fermented beverages from RandT crops are still in very infant stage, RandT crops have not gained the industrial importance in production at national level yet. Taro, yam, cassava and ground apple also serve as supplementary food sources for the farmers at different communities. In the past, almost all of the RandT crops were the food of cultural occasions and to some extent regular food for marginalized poor, however, with the increased awareness towards the value of these crops, rapidly urbanized population in recent years and their changed food habits have started to diversify their food intake from normal cereal-based diets to greater consumption of root and tuber crops. Besides the food and nutritional importance, some RandT crops are very important for celebrating religious festival such as '*Maghe Sankranti*', the first day of the month '*Magh*' (mid-January). Taro and sweet potatoes are used as pure and holy food during fasting especially in *Thulo Ekadashi* during *Kartik*. There is year-round availability of these tuber crops in local markets which signifies the increasing importance of RandT crops in Nepal. Despite their importance in income generation, food and nutritional security and to some cultural context, little research and development attention have so far been given to these crops.

## Major Root And Tuber Crops Varieties in Cultivation Practices

Root and Tuber crops contribute as source of food and nutrition as they produce large quantities of dietary energy

and have stable yields under conditions in which other crops may fail. Though, further investigation might be necessary to find out the centre of origin of these crops, most of RandT crops possess a huge genetic diversity at variety and landrace levels in Nepal. This diversity can be found in almost all of the agro-ecologies. RandT crops contain mainly carbohydrates (16-24% of their total weight) with some protein and fat (0-2% each). There are more than 30 edible and non-edible RandT crops reported in the world and among them, taro (*Colocasia esculenta* L.) Schott), Yam (*Dioscorea alata* L.), Cassava (*Manihot esculenta* Crantz), Elephant Foot Yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson), Yacon (Peruvian Ground Apple) (*Smallanthus sonchifolius* (Poepp.) H. Rob.) and Sweet Potato (*Ipomoea sp.*) are the major cultivated RandT crops in Nepal (Table 1.). A total of 77 sweet potato germplasm consisting of 22 exotics and 55 locals are maintained under field condition. The variety of sweet potato released by Seed Quality Control Center (SQCC) and the variety of sweet potato and taro maintained at Nepal Agriculture Research Council (NARC) in Nepal is mentioned hereunder (Table 2 and 3).

**Table 1:** Major R and T Crops Seed Varieties in Cultivation Practices

S.N.	Root and Tuber Crops	Local cultivars/Germplasms
1.	Yam	Sarlahi Red, Pangnang (Yellow and White), Jante (Hatti Paile), Hatti Dare, Patale, Ban Panang, Ban Tarul
2.	Taro (Colocacia/Arum)	Panchamukhi, Dudhe, Hatti Pau, Khari, Chiple (Singane), Okhale (Pong), Hatti Sunde
3.	Elephant Foot Yam (Ole)	Gajendra, Local
4.	Sweet Potato	CIP 440099, CIP 440020, CIP 440015, CIP 4400513, Local White, Local Brown, Local Red, Japanese Red, White Round, Helen Yellow
5.	Cassava/Tapioca	Red, White
6.	Yam Bean	Rajendra Misrikand-1, Mexican, Indian Local
7.	Bhyakur	Rani Bhyakur, Chuiyan Bhyakur
8.	Gittha	Local Bitter, Local Sweet
9.	Suthuni	Local

**Table 2:** Variety of Sweet Potato released by SQCC in Nepal

S.N.	Crops	Variety	Released year	Remaks
1.	Sweet Potato	Suntale Sakharkhand 1	2076	High beta-carotene content
2.	Sweet Potato	Suntale Sakharkhand 2	2076	

**Table 3:** Variety/germplasm maintained at NARC in Nepal

S.N.	Crops	Number of Variety/Germplasm	Remaks
1.	Sweet Potato	20	Local collection
2.	Sweet Potato (OF)	11	CIP, Peru
3.	Taro	54	Field Gene bank, Khumaltar

Root and tuber crops are very much adaptive in low input agricultural systems and important for food and nutritional security. Rural people mostly involved in utilizing root and tuber crops and they maintain the traditional knowledge regarding their location, season, preservation, processing and culinary uses. Nepal has diverse agro-ecological and climatic conditions favourable for the production of RandT crops but are considered as underutilized crop species. RandT crops particularly sweet potato, taro and yam contribute a major share in the traditional food systems of many people in Nepal and these crops play a major role in the food security of the people especially in mid and High Hills of Nepal. The production of yam, taro and sweet potato still depend on local varieties.

### Propagation Techniques of Root and Tuber Crops

Root and tuber (RandT) crops are perennial crops but are also cultivated as an annual crop as they are ready to harvest in 8-10 months. Suitable and productive varieties can be developed and expanded through the propagation of these crops by collection, conservation and promotion of RandT crops. Propagation of a crop is a technique that helps to increase the number of plants which ultimately help to coverage the land under improved cultivars and can get the desired properties such as higher yield, bigger fruit, sweeter, tastier to eat and better price in the market.

This article mentions about propagation techniques of some major RandT crops cultivated in Nepal.

## 1. Propagation technology in yam

Propagation in yam is done from tuber. Planting tuber is called Sett (Fig. 01). The size of the sett has a big impact on the production. It has been found that small size tubers produce less while large size tubers produce more. Similarly, the planting part of the sett also seems to affect the yield.

Planting the upper part of yam i.e. head (Crown) yields more, while planting the lower part i.e. tail (Tail) yields less. So, when cutting the seed, remove the bottom half of the yam and slice the upper half in to sett pieces with transverse cuts (cross-sections).

It should be planted only after keeping it immersed in Dithane M-45 pesticide at the rate of 1 gm per liter of water for 5-10 minutes.

### Propagation method

#### Step 1: Choosing the mother seed yam

- The weight of mother seed yam should be between 500 grams to 1 kg.
- Tuber should be sprouted, healthy and not rotten.
- Must be free from diseases, insect-pests and nematode.



Fig 1: Planting tuber of Yam

#### Step 2: Make pieces of mother seed yam

- Materials needed to slice the seed yam: sharp knife, pesticides, and tuber.
- Seed yams should be cut rounded.
- The size of each cut piece should be 6 cm. X 6 cm.
- Then each piece should be cut into strips and each piece should be of uniform size.
- Each set should weigh between 25 to 50 grams.

#### Step 3: Treatment and planting of the cut set

- Materials needed during treatment: cutting set, ash, chemicals, water, basket, gloves.
- The cut set should be treated with fungicide. Ash can also be used instead of pesticides.
- Then the set should be placed in a basket and immersed in the pesticide solution for 5-10 minutes.
- Now after draining the water from the basket and the treated sett should be dried by keeping it in the shade then only planted.

## 2. Propagation technology in cassava

- Propagation in cassava (Fig. 02) is done by cuttings of branch called sets.
- Disease free, 8-12 months matured, 2-3 cm. thick stemmed sets are considered suitable for planting.
- The lower or upper soft part of the branch is not suitable. Therefore, if you plant the middle part, there is more chance of survival.
- The 1/3 part of stem from uppermost area of branch and 5 cm from lower region should be cut and removed.
- It is best to plant middle part of the stem (Fig. 03).
- When cutting the set, the lower part should be rounded and the upper part should be cut slanting so that it is easy to identify when planting.
- Set should be of 25 - 30 cm. in length. There is a lot of reduction in the production when planting set length is of 10 cm.
- Storing the sets in shade for 15 days gives good sprout.



Fig 2: Cassava Plant

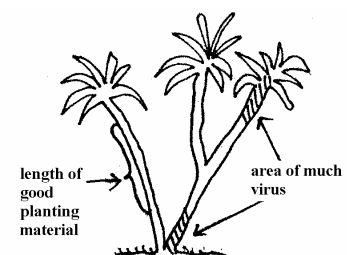


Fig 3: Planting material of Cassava

### 3. Propagation technology in taro

- Propagation of taro is done by large and small corms as well (Fig. 04).
- Propagation should be done with healthy corms of uniform size weighing 20-25 gm free from diseases.
- It has been found that planting seeds of small weight results in less production, while planting seeds of heavier weight produces more.
- At present, to reduce the seed rate, small corms are kept separately from the fruit and at the time of planting, cutting it into two pieces from the head and then cutting it horizontally into two pieces from the middle, it is also a practice to plant a mini set of 10 grams.
- When planting, cut corms should be treated with Indophil-45 fungicide at the rate of 1 gm per liter of water for 20 minutes and dried in a shaded place.



Fig. 4: Corms of Taro

### 4. Propagation technology in sweet potato

- Propagation of sweet potato can be done by planting whole sweet potato tuber or cuttings of stalks (Fig. 05).
- But if cuttings are taken from the same stalk and applied again and again, there is a possibility of mite attack.



Fig 05: Planting material of Sweet Potato

- Therefore, it is better to plant sweet potatoes in the bed and prepare a new stalk.
- Stalks of mature sweet potato are the best to use as planting material for propagation.
- The upper part of the stalk i.e. towards the tip should be used for propagation. It has been proved from various trials that more growth and larger size tubers are obtained.
- There should be 25 cm long stalk from tip with 3-4 nodes.
- Before planting, overnight soaking of stalk in a solution of fungicide like Carbendazim at the rate of 2 ml per liter of water will improve germination and prevent seed borne diseases.
- Planting of stalk should be maintained at a distance of 60 cm. x 25 cm

### 5. Propagation technology in elephant foot yam (ole)

- Propagation of elephant foot yam can be done either by Sett or Corm (Fig. 06).
- It is customary to plant Mini Sett weighing up to 100 grams for seed production.
- 15 Mini Setts are produced from 1.5 kilogram of ole.
- Planting of Mini Sett at 45 cm. X 30 cm spacing yields up to 1 kg in 6-7 months which is good for seed next year.
- Planting Setts or corms of 750 gm to 1000 gm is recommended for higher yield.
- If cut parts of a large seed are to be sown, it should be treated with Trichoderma mixture in cow dung solution and sown.
- At the time of planting (March-April), large seeds are cut into pieces of 750-1000 grams, mixed with cow dung or wood dust and dried in a shady place for a few hours and sown.



Fig. 06: Sett of Ole

### 6. Propagation technology in yam bean (Mishrikanda) Pachyrrhizys erosus

- It is propagated by seeds which are contained in pods (Fig. 07).
- A pod length is up to 7 to 15 cm. and contains up to 8-10 seeds.
- Seeds are brown or red.
- Seed is flat rather than round.
- Seed rate: It usually takes 20-60 kg / hectare. The seed rate depends on the distance of planting, the time of

planting and the purpose for which it is planted.

- Generally, it is sown in the month of June-July (*Jeshta-Ashadha*) and harvested in December-January (*Mangsir-Poush*)
- Its sowing time is from June to September (*Jeshta-Ashwin*) according to its purpose:
  - For seed production it is planted in early June at the distance of 30 cm x 30 cm.
  - For tuber production it is planted in August-September (*Bhadra-Ashwin*) at a distance of 30 cm x 15 cm. or 15 cm x 15 cm for small tuber and 60 cm x 45 cm or 60 cm x 60 cm for large size tuber.



**Fig 07:** Pods of Yam Bean

- When planted late, the tuber is small, so there is no problem of tuber cracking, but the yield is low.
- Mexican and Indian local varieties are in cultivation. The Mexican variety has a large size tuber and its weight is up to 1.52 kg. but it is less sweet in taste and tuber cracking is often observed.
- Indian local variety is of 200-300 grams but it is softer, the fiber is less, the shape of the tuber is conical, the pulp is white, the bark is soft and cream in color and tuber cracking is less.
- Rajendra Misrikand-1 variety of India is an improved variety. The production of this variety is 40-55 tons per ha. and the tuber crop is ready in 110 to 140 days. One tuber weighs up to 600-700 grams. It is very soft, sweet and the tuber does not crack.

### Diversification of Root and Tuber Crops

Root and tuber (RandT) crops are of diverse uses. On a global basis, approximately 45% of root and tuber crop production is consumed as food and in the form of various delicious dishes as well (Fig. 08), with the remainder used as animal feed or for industrial processing for products such as starch, distilled spirits, and a range of minor products.

Pudding (Philippines)	Doughnut (Philippines)	Cake (Philippines)
Haluwa (India)	Pudding (USA)	Pieces of Cake
<b>Fig. 08:</b> Various food dishes of R and T Crops (Yam)		

Root and tuber crops are indispensable in the field of agriculture. These crops provide essential nutrients, income opportunities, and resilience for farming systems worldwide. Their adaptability and ability to grow in diverse environments make them a cornerstone of food security, particularly in regions vulnerable to climate change. As the global population grows, root and tuber crops will remain essential to feeding communities and supporting sustainable, diverse agricultural practices.

They are important food crops that have gained increased importance due to their role in food security, their ability to withstand drought as well as their potential for commercial processing. It can be processed into flour, animal feed, or even biofuel. Sweet potato leaves are also edible and nutritious, adding more versatility to the crop. There's a growing demand for both cassava and sweet potatoes in various industries, from food processing to starch production. Cassava and sweet potatoes are a step towards a sustainable future for agriculture and food security.

The main nutritional value of roots and tubers lies in their potential ability to provide one of the cheapest sources of dietary energy, in the form of carbohydrates, in developing countries. They provide a substantial part of the world's food supply and are also an important source of animal feed and processed products for human consumption and industrial use.

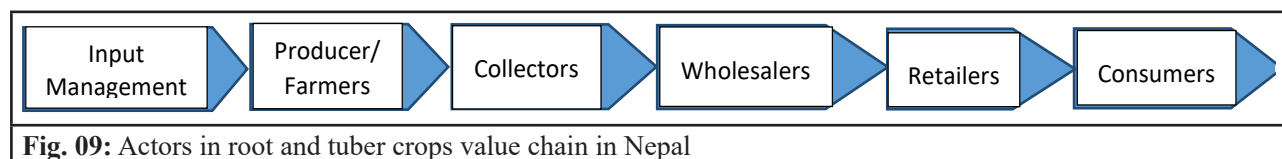
Growing root and tuber crops contribute to agricultural biodiversity, reducing dependency on cereal grains and increasing dietary options/choices. This crop diversity makes farming systems more resilient to pests, diseases, and climate fluctuations. For instance, rotating root and tuber crops with other crops can break pest cycles and improve soil health.

### Value Chain Issues in Root and Tuber Crops Seed

The major value chain actors include Input Suppliers, Farmers, Farmers Groups, Cooperatives, Traders (collectors, wholesalers, retailers), and Service Providers. There are 18 major markets for root and tuber crops along with other vegetables located at Birtamod, Biratnagar, Dharan, Dhankuta, Golbazaar, Dhalkebar, Bardibas, Lalbandi, Kalimati, Benighat, Bharatpur, Pokhara, Butwal, Tulsipur, Birendranagar, Kohalpur, Attariya and Kanchanpur and cooperatives and farmers of some production pocket areas.

#### 1. Actors and functions

Key actors identified included individual farmers, farmers' groups, cooperatives and traders at different stages (collectors, wholesalers, retailers). Input suppliers and service providers were also among the key actors in the chain. Fig. 09 presents the key actors in root and tuber crops value chain in Nepal.



**Fig. 09:** Actors in root and tuber crops value chain in Nepal

#### 1.1 Input Management

Agricultural inputs, primarily planting materials in root and tuber crops are mostly managed by farmers themselves. In case of yam, the upper crown is used as seed which is kept intact in the soil and also the arial fruits of yam called mirek are also used as planting material and mostly managed by farmers themselves. Mostly organic manure and some quantities of chemical fertilizers are used buying it from local agro-vets and cooperatives.

#### 1.2 Producer

There are basically two categories of producers in production areas i.e. subsistence and commercial producers. Subsistence farmers generally produce some of the root and tuber crops depending on family need and family interest for home consumption and for festival use. Some surplus produce is sold to local *haat bazaar* and local shops. Commercial farmers cultivate root and tuber crops and sell their produce to known collectors or cooperatives. There are no any set arrangements to make the marketing based on contract. Farmers have no technology of creating price advantage over time.

#### 1.3 Collectors

Collectors are the key actors of the root and tuber crops value chains who are involved in collecting from production pocket to the wholesale markets. Their trading activities include: buying and assembling, repacking, sorting, selling to middlemen/or, transporting and selling at market centers in cart or pick up and sell to the wholesalers or wholesale markets. Both collectors and growers make a kind of mutual agreement for price negotiation.

#### 1.4 Wholesaler

Wholesalers are mainly involved in buying root and tuber crops from the collector and supplying them to the retailers. They also store products, usually for a maximum of one to two week. They are mainly located in major markets of Birtamod, Biratnagar, Dharan, Dhalkebar, Lalbandi, Kalimati, Narayanghat, Pokhara, Butawal, Birendranagar, Kohalpur, Dhangadhi and Kanchanpur where there are market hubs with some infrastructure such as office buildings, open stores, transaction sheds, and shop sheds. These market hubs are usually established with

government support and operated by local market management committee.

### **1.5 Retailers/vendors**

Retailers and vendors are the other important actors with close linkages with the wholesalers and the consumers. Their involvement in the chain includes buying of root and tuber crops, transporting to their retail shops, grading, displaying and selling to the consumers.

### **1.6 Consumers**

Consumers are the individual households, hotels, army camps and police quarters who buy and consume root and tuber crops occasionally during some festivals and also a little quantity as regular items during the season.

## **2. Enablers and facilitators**

In a value chain, the enablers provide regular support services or represent the common interest of the value chain actors. Functions at the enabler level include public research and technology development, promotional services, marketing or advocacy and other support service providers. These enablers and facilitators are public actors, private actors and NGOs.

### **2.1 Public actors**

Public actors at higher level, business enablers are Ministry of Agriculture and Livestock Development (MoALD), Department of Agriculture (DoA), Ministry of Industry, Commerce and Supply (MoICS). These institutions facilitate policy formulation and bilateral trade agreements with other countries. Nepal Agricultural Research Council (NARC) and National Center for Potato, Vegetable and Spice Crops Development (NCPVSCD) and Tuber Vegetable Development Center (TVDC), Sindhuli are working to develop new varieties and disseminate different technologies in root and tuber crops. Gene Bank /NARC is involved in collection, evaluation and variety development. Agriculture Knowledge Centers works as technical supporters to the producing farmers. Provincial ministries and local government facilitate policy and program support.

### **2.2 Private actors**

Federation of Nepalese Chamber of Commerce and Industries (FNCCI) and Agro Enterprise Centre (AEC) is working in the area of market development by providing market information and facilitating for market linkages, etc. At traders' level, major market centers are supporting for business successes by providing market information. Some NGOs such as Local Initiative for Biodiversity Research and Development (LI-BIRD) and cooperatives and farmers' groups are also maintaining the local land races at community level.

## **3. Value chain governance**

The value chain governance of root and tuber crops in Nepal is heavily dependent on occasional demand during festivals and rituals. Therefore, the value chains are highly influenced by the particular demand time and supply from local producers and import from India. In most cases, the business relations between the various operational actors are of both special contract and free market exchange. Due to the lack of a proper contractual market system and minimal bargaining power, farmers are forced to sell their product at the price offered by the traders. Traders usually refer to Indian markets for price fixation. In some cases, there are conflicts among the traders and farmers regarding payment and failure to keep their commitment. Overall, the governance of the root and tuber vegetables value chain is buyer driven with minimum trust between various actors. Traders are always complaining that the farmers are not providing quality product while farmers are blaming the traders for offering low prices.

## **Conclusion**

Root and tuber crops are the significant component of the Nepalese food system. Due to their high starch content and calorie, these crops play a major role in food security of small and marginal farmers and the ethnic people. Local landraces of RandT crops are tolerant to biotic and abiotic stresses and have wide adaptability to diverse agro-climatic conditions. Nepal has suitable climate and comparative advantages for the production of different kinds of root and tuber crops. Farmers are looking for high quality planting materials. The cultivation techniques (agronomy, tuber physiology, propagation, storage and postharvest, etc.) of RandT crops must be studied for enhancing the production and overall utilization should be promoted to improve the variety as well as livelihood of rural people. Indigenous knowledge residing in farm communities about RandT crops must be explored and documented. The industrial usages of RandT crops should also be explored and disseminated to rural communities. Government policies should give high priority in plans and policies for conservation and promotion of RandT crops thereby; public institutions mandated to RandT crops prioritize the research activities (exploration, collection, and multiplication, characterization at morphological, molecular and functional compound levels) and their maintenance

at field, in-vitro and Community Field Gene bank. Nepal needs to study province wise internal demand and in country production status, balance sheet status; study external demands for raw root and tuber crops to produce, flour and powder products, encourage private sectors for opening industries along with commercialization of the produces. The government should encourage farmers for increased production by providing some incentives or subsidy in some inputs for few years.

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