

Present Status of Seed (Potato and Tuber Crops) Research, Varietal Development and Future Perspective in Nepal

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Abstract

Potato (*Solanum tuberosum L.*) is an important vegetable crops of Nepal. It is the major component of vegetables of Nepalese people. The crop is being cultivated in the country throughout the year. Significant increase (from 20 kg to > 100 kg/person/year) in Per capita consumption of potato in Nepal shows the growing demand of potato within country. Besides, country has opportunity to get advantage from this crop by exporting to giant markets in neighboring countries. Major areas to be improved in the potato sector development is to strengthen its seed production system along with development of market preference variety. Research and development activities in potato was started since 1960s. Major seed sector research in tuber crops has been confined to potato though in beginning stage. Research to increase the quality, size and number of Pre-Basic-Seed (PBS) was initiated since the establishment of Nepal Agricultural Research Council (NARC). Similarly, varietal effect on the seed multiplication ratio, number of seed potato and their storability have been studied. Study on the effect of plant density, PBS generation and pruning in seed potato production have been done and recommended for seed production. Since the establishment of formal research and development program by then Government of Nepal, many genotypes of potato have been brought in the country and evaluated for the suitability in different agroecological regions. In later years, research on varietal development activities have been focused on disease and insect resistance, early maturing, good storability, suitability for processing, climate resilient and high yielding qualities. So, far thirteen varieties of potato released, and five varieties registered. Research on sweet potato varieties has been initiated. As a result of evaluation of exotic and local germplasm of sweet potato, two varieties have been released and few are in pipelines. Different research stations are involved in Collection and evaluation of germplasm of ole, yam and Colocasia. Ever increasing internal demand, and scope of marketing in neighboring countries are the big opportunities to increase the production and productivity of potato and other tuber crops in Nepal. This can be achieved by making strong seed system, utilizing the potentiality of agrodiversity, speed breeding using new breeding tools and product diversification.

Keynotes: Basic seed, Constraints, Generation, Seed replacement ratio.

Introduction

Potato (*Solanum tuberosum L.*) is one of the most important crops of Nepal used in every kitchen of Nepalese family and consumed as both staple food and vegetable. It ranks first in terms of productivity, and second in area of cultivation and production after rice. The present productivity of potato in Nepal is 17.23 ton/hectare which is mainly due to the use of new varieties, improved cultivation technologies and clean seed potato (though not sufficient). In Nepal, potato can be produced throughout the year by utilizing the genetic and agroecological variation which ranges from 100 to more than 3000 masl. The area coverage of potato cultivation in high hills and mountain, Mid-hills and Terai is estimated as 18%, 42% and 40% respectively. Per capita consumption of potato in Nepal was estimated as <20 kg/person/year during 1990s which has been significantly increased to 90-95 kg/person/year in 2022.

The total production of potato is 3410829 MT from 198256 hectare of land with the productivity of 17.23 mt/ha. The seed replacement ratio (SRR) of potato in Nepal is 15% where the contribution of improved varieties in Nepal's total potato production is 51%. Formal research and development in Potato in Nepal was initiated during 1962 by establishing the potato farm in Nigale and Jaubari and formal official attempt was done by establishing the National Potato Development Program (NPDP) in 1972. After the establishment of Nepal Agricultural Research Council (NARC) as an autonomous body to conduct the higher study and research in agriculture, wings for potato research was put under NARC as National Potato Research Program (NPRP) in 1991. Since the establishment NPRP is involving in different research activities in potato and sweet potato, production, and distribution of pre-basic and basic seed of different varieties of potato.

Major Constraints of Potato Production in Nepal

The national average yield of potato in Nepal is low (17.23 mt/ha) as compared to other countries like USA (51.45 mt/ha), Sweden (36 mt/ha), India (25.79 mt/ha), Pakistan (24.43 mt/ha) and China (20.45 mt/ha) (FAO, 2023). A significant sum of national currency has been expensed to import large amount of ware potato, seed potato and potato products. The import can be reduced if the productivity of potato is increased. The major constraints which should be managed to increase the production and productivity of potato in the country.

Lack of early maturing and high yielding varieties

The varieties/genotypes of potato which are grown in Nepal are of long or medium maturing types. Nepalese farmers are demanding early maturing varieties (70-90 days) to fit this crop for their cropping system. Majority of cropping systems in Nepal are Maize or rice-wheat (high hills), Maize or rice-Wheat/or mustard (mid hills) and Rice-Wheat or legumes/mustard (in Terai). Farmers do not want to sacrifice the main crops which previously established in their cropping system that's why the area expansion under potato is not so rapid. They have preferred to incorporate the potato during the gap period between two major crops. Since the gap period is short, early maturing potato with higher yield could be the best option. And soil moisture management for potato will be easy because of the higher residual soil moisture after rainy season crops.

Inadequate availability of quality planting materials

Most of the farmers in Nepal are cultivating the potato using degenerated seed potato causing significant yield reduction. Almost 50% of total potato production area is covered by improved varieties. Majority of potato growers use the potato tubers saved for seed from generations or purchase the seed from market with no certification. More than 400 thousand metric tons of seed potato is required in Nepal. The productivity of potato can be increased by at least 25% using quality seed potato.

Informal seed production and limited distribution system

The demand of seed potato of different varieties is estimated as around 4 lakhs metric tons (as calculated with the total production 3.4 million tons with the seed multiplication ratio of potato as 8.5). The supply of seed potato to the farmer is very limited. Seed potato is produced through community-based seed producer group in few districts and distributed locally. The quantity of seed produced by farmers and farmers group is not sufficient even for district. Pre basic seed (PBS) has been produced by government laboratories (NPRP and PDC, Nigale) as well as few private laboratories after getting the license from Seed Quality Control Center (SQCC). Adoption of seed cycle through PBS to different generations of basic seeds (Basic seed 1 to Basic seed 4) is very weak. Seed cycle maintenance and seed distribution system has not been well established. Most of the potato seeds in mid hills and terai are sold in market without seed certification.

Limited nutrient, disease, pest management and mechanization practices

Potato is heavy feeder crop and demands higher nutrients. The availability of chemical fertilizers during potato cultivation is limited and on the other hand farmers are using very fewer chemical fertilizers than recommended dose. Many fungal, bacterial, and viral disease attack the potato crops and significantly reduce the yield. Because of the use of degenerated seeds, poor management practices, the yield of potato at farmers field is very low. Late blight is one of the major diseases causing the losses in farmer's field. Similarly, plants with viral infection have very less yield. Among major insect pest, aphid is one of the dominant insects helping the transfer of the viral disease from diseased to healthy plants. Due the land fragmentation and small land holding size of Nepalese farmers, mechanization in potato farming is quite difficult. Majority of potato growers in Nepal are using manual labor in almost all the activities in potato cultivation which have led to higher cost of production.

Limited seed storage facilities in the country

The availability of cold storage for fruits and vegetables are limited in the country. Potato needs special temperatures for different purpose of utilization. Seed potato, ware potato and potato for processing purposes need 2-4°C, 4-7°C and 7-12°C of storage temperatures, respectively. The quality of potato is highly influenced with the storage temperatures and duration. Many of the storage facilities in Nepal store the potato along with other commodities. Seed potato storage needs special environment and separate structures to maintain the seed quality which is not available in the country.

Lack of processing varieties

Significant quantities of potato and its products have been imported in the country. Most of the products are starch, frozen potatoes, and processed foods. Recently few potato-based industries have been established in the country. These industries have utilized the potato from abroad because of the no or very low production of potato with

processing qualities. NPRP has recently been started to develop the variety for processing qualities. Availability of quality seeds of potato varieties with processing qualities (Chips, French fries etc.) should be increased in the country to supply the raw materials to the industries.

Status of Seed Potato Research in Nepal

Majority of research on potato and tuber crops are focused on potato crop variety and its crop husbandry. Limited research has been conducted in postharvest handling, storage, and processing. There are very limited researches conducted on seed potato production.

An experiment was conducted to study the losses in seed potato under different storage conditions. The results showed that the shrinkage loss in seed potato was highest (in all tested varieties) under Diffused light storage condition. Rate of sprouting varied according to variety and field performance was recorded better in the variety with longer dormancy period (Dhital et al, 1996). Similarly research was conducted (Dhital and Ghimire, 1998) to study the effectiveness of different storage methods for seed potato. Three storage methods viz cold store, diffused light storage under room conditions and under ground pit storage were used to store the seed potato. The result showed that cold storage (at 3-7°C) was superior to other two methods in terms of plant vigor and yield irrespective of varieties. Dhital and Wilcockson, 2004 reported that yield potential of seed potato stored under Diffused light storage was reduced to a large extent than cold stored seed tuber because of advanced physiological aging of seed potatoes.

Research on Pre-Basis Seed (PBS)

Performance of *in vitro* plantlets and their yield performance in glasshouse was studied to produce *in vitro* plantlets using 3% sucrose and sugar in different MS media. The results showed that the performance of plantlets in *In vitro* as well as in glasshouse was found indifferent when sucrose is replaced by sugar (Sakha et al, 2008).

To identify the low-cost technology in production of *In vitro* plantlets, an experiment was conducted to produce the increased number of plantlets in a single bottle. The result showed that higher useable nodal explants were produced when 10 plantlets/bottle (in 400 ml capacity bottle) were cultured as compared to 12 and 15 plantlets/bottle (Sakha et al, 2008).

A comparative study to produce pre-basic seeds of potato was conducted at the Khumaltar, Lalitpur. The Yield of PBS by using *in vitro* plantlets and stem cuttings under different crop geometry in glasshouse showed that the *In vitro* plantlets gave 5 mini tubers/plant while it was only 2 per plant in cutting plants. But the average weight of mini tubers was 2.8 g and 8.7 g respectively in the tubers produced from *in vitro* plants and cuttings. Similarly, the effect of different crop geometry to plant the plantlets were studied. This study revealed that the number of tubers per square meter were higher (294/m²) in 10x10 cm spacing (Sakha and Rai, 2004).

Table 1. Effect of Season on Rapid multiplication of Virus Free Plantlets under Glass house and Screenhouse conditions for Spring and Autumn Production in Khumaltar, Lalitpur (Dhital et al, 2010)

Parameters	Spring		Autumn	
	Glasshouse	Screen house	Glasshouse	Screen house
Contamination of subculture (%)	6.2		9.2	
Rate of regeneration (%)	89.2		95.2	
Mortality of transplanted <i>In vitro</i> plantlet (%)	8.7	9.4	7.0	6.2

Study on Crop geometry for Basic Seed Production

A study to identify the suitable crop geometry for basic seed potato production was conducted in Jumla (2250-2300 masl) using different spacing. The result of the experiment showed that potato tuber planted at 50 x 20-25 cm gave the higher number of seed size tubers (44/m²) as compared to recommended spacing (60 x25 cm) (31/m²) (HRS, 2021).

Status of varietal research in potato and tuber crops

Potato is one of the most important crops of Nepal after Rice, Wheat, Maize, and Millet. It ranks first in Productivity, second in production and fifth in area under cultivation among the cultivated crops in Nepal. Although potato was introduced in Nepal almost 300 years ago, the formal program for its development was initiated during 1960s. For the concentrated effort in Potato development in Nepal, National Potato Development Program (NPDP) was established under ministry of Agriculture in 1972. Through this program, Swiss Development Cooperation, and

International Potato Center (CIP), Peru, many activities in varietal introduction, seed tuber production, evaluation of True Potato Seed (TPS) families were conducted which gave the opportunity to introduce many potato varieties in Nepal. With the establishment of Nepal Agricultural Research Council (NARC) as an autonomous research organization in 1991, NPDP was divided as Potato Research Program (PRP) and Potato Development Program (PDP). With the continuous effort, till now 13 varieties of Potato have been released and recommended for the cultivation in different agroecological regions.

In initial years, effort in variety selections were given for higher yield and disease resistance. Later added efforts have been given as drought tolerant, higher storability, short maturity, longer dormancy and processing qualities. Recently in 2081, two processing varieties viz. Khumal Seto-3 and Khumal Rato-4 have been released which are also suitable for processing (Making potato Chips).

Besides, five varieties, which are very popular among farmers as well as consumers have been registered and recommended for the cultivation in different agroecological regions.

Table 2: Released and Registered varieties of Potato in Nepal

Varieties	Year	Source	Domin	Remarks
Kufri Sindhuri	2049	India	Terai	Released
Kufri Jyoti	2049	India	Mid and High hills	Released
Desire	2049	Netherland	Terai-High hills	Released
Khumal Seto 1	2055	CIP	Mid and High hills	Released
Khumal Rato 2	2055	CIP	Terai	Released
Janak Dev	2055	CIP	Terai- Hills	Released
Khumal Laxmi	2065	CIP	Mid Hills	Released
IPY 8	2065	CIP	Terai and Inner Terai	Released
Khumal Upahar	2070	CIP	Terai	Released
Khumal Ujwal	2070	CIP	Mid hills	Released
Khumal Bikas	2075	NPRP	Mid and High Hills	Released
Khumal Rato-4	2081	CIP	Mid and High Hills	Released
Khumal Seto-3	2081	CIP	Terai and Mid Hills	Released
Cardinal	2076	Netherland	Terai-High Hills	Registered
Rosita	2076	Switzerland	High Hills	Registered
MS. 42-3	2076	CIP	Terai and Mid Hills	Registered
TPS 1	2070	CIP	Hills	Registered
TPS 2	2070	CIP	Hills	Registered

(Source: NPRP 2023)

In Recent years, three varieties of Potato suitable for French Fry production have been registered with the combined effort of National Potato Research Program (NPRP) and First Food Choice (a private potato processing company).

Table 3: Registered Potato Varieties suitable for French Fry Production with their postharvest quality

Varieties	Specific gravity	Dry matter content	PWL % @90 DAS	reducing sugar (mg/100gm)
Alverstone Russette	1.08	22.53	7.85	10.444
Innovator	1.09	24.54	9.31	10.418
Sagitta	1.08	22.49	9.60	3.662

(Source: NPRP, 2023)

Varietal Development in Sweet Potato for Food and Nutrition Security

Sweet Potato (*Ipomoea batatas* L) is one of the high energies containing food. Although, this crop has very potential for reducing food and nutritional security in Nepal, this crop has not got very focused program. This crop has been cultivated in marginalized and neglected field in Nepal. Realizing the importance of this crops as a climate resilient, high yielding as well as high energy food, NPRP has initiated the research work in variety development of sweet potato. As a part of variety development collection of locally adopted germplasms, their evaluation and utilization are going on. Besides, different genotypes from International Potato Center (CIP), Lima Peru were brought at the Program. With the continuous evaluation of sweet potato genotypes, two varieties (Suntale Sakharkhanda-1 and Suntale Sakharkhanda-2) have been released for cultivation. Overall, 38 different sweet potato genotypes have been conserved under field conditions in NPRP, Khumaltar in 2023/24. The important characters of released sweet potato varieties is given below.

Suntale Sakharkhanda -1

- High yielding (13-15 t/ha) than check varieties
- Semi compact plant type (vine length)
- Higher farmer's preference
- Beta carotene and other mineral content: high (40.95mg/100gm), (Japanese red low(3.57mg/100gm), local check- 2.24mg/100gm)
- Total mineral content high (3.62%)
- Low tuber damage by insect pest
- Attractive root shape, size, skin and flesh color
- Good for Salad purpose and practiced for preparing pickles, juices, bread and biscuit

Suntale Sakharkhanda-2

- High yielding (18-25 t/ha) than check varieties
- Higher farmer's preference
- Beta carotene and other mineral content: high, Carotene-17.58mg/100gm, total minerals-(3.87%)
- High protein content-3.14%
- Low tuber damage by insect pest
- Attractive root shape, size, skin and flesh color
- Good for Salad purpose and practiced for preparing pickles, juices, bread, and biscuit

The varietal evaluation in different stages of experimentation is going throughout the country. Some of the major varieties with their characteristics in Coordinated Varietal Trial have been given as:

Table 4: Morphological Characteristics of Sweet Potato Genotypes under Coordinated Varietal Trial (CVT)

Genotypes	Plant type	Vine color	Mature Leaf color	Shape of central lobe
Benshisahar White	spreading	green	green with purple edge	semi-elliptic
CIP 105085.2	semi-compact	green	slightly purple	elliptic
CIP 105086.1	semi-compact	green	green	lanceolate
CIP 106861.3	spreading	totally dark purple	yellow-green	teeth
CIP 106906.1	semi-compact	green	slightly purple	linear (narrow)
CIP 187020.1	spreading	totally dark purple	green with purple edge	semi-elliptic
CIP 194540.5	spreading	green	green with purple edge	traingular
CIP 199062.1	semi-compact	green	slightly purple	linear (narrow)

CIP 440132	spreading	green with many purple stripes	greyish (due to heavy pubescence)	triangular
CIP 440293	extremely spreading	green	green	teeth
Kimichaur Seto	spreading	mostly purple	slightly purple	teeth
Suntale Sakharkhand-1	erect	green	slightly purple	elliptic

Status of varietal research in colocasia and yam

Different types of Colocasia and Yam have been cultivated throughout the country with their local name. The same landrace has different name in different location. Variations among the landraces have been observed. Locally cultivated landraces of Colocasia in Gandaki Province were collected and evaluated at Horticulture Research Station, Malepatan, Pokhara. With the continuous evaluation (performance, phenotypes, genotypes), one landrace is going to be registered. There are 16 landraces of Colocasia collected at the station. The major characteristics of corms and cormels of collected landraces is given in Table 5.

Table 5: Corms and Cormels characteristics of Colocasia landraces collected from the different districts of Gandaki Provinces at Horticulture Research Station (HRS).

Sl. No	Land races	Major corm /cormel characteristics
1	Hatti Paun (Elephant foot)	Brown color, Multi-faced (Many Eye bud in a corm), Round shaped corm, fewr cormel numbers.
2	Bhainsi Khutte (Buffalo foot)	Flattish round brown corm, medium number of cormlets, and medium sizedcrom.
3	Bermeli Pidalu	Red and round shaped medium sized corm, cormlet Number medium
4	Chhattare Pidalu	Brown medium size corm, more corm let number with longshaped
5	Dudhe Pidalu	Round and brown corm, corm let number more
6	Thado Mukhe (Errecta)	Long shaped corm, number of cormlet, brown in color
7	Khujure	Oval type brown corm, corm let number more
8	Rato Bhale (Red cock)	Red in color, small size corm, corm let number more and longin shape
9	Sat Mukhe Pidalu (Seven faced)	Multi faced (Many eyed bud in a corm), less corm lets, c Shape flatish round
10	Rato Mukhe (Red faced)	Red and round shaped corm, corm let number medium
11	Pancha Mukhe Pidalu (five)	Flattish round brown corm, no corm lets
12	Lahure Pidalu	More corm let number, small size corm, brown colored round corm
13	Gante Pidalu	Round and medium sized corm, higher number of corml
14	Chhaure Pidalu	Brown and small corm, maximum numbers of cormlets
15	Khujure Rato Pidalu	Medium Brown oval shape corm, corm let number more
16	Thaune Pidalu	Big oval shaped corm, fewer number of cormlet, brown i color

(Source: HRS, 2019)

Very little works have been done in Yam. Few landraces collected from the vicinity of Pokhara have been maintained and evaluated at the HRS, Malepatan. Few landraces were also brought from Horticulture Development Center (HDC), Sindhuli. HDC has also collected and evaluated the land races of Colocasia and Yam. The center is also involved in the promotion of their cultivation through technology transfer and seed distribution.

Strategy to Promote Variety Development and Seed Production

- Strengthen the breeding programs in the country through personnel capacity building and infrastructure improvement
- Develop models for private investors to adopt public varieties/ advanced breeding lines on short term exclusive rights basis to allow for cost sharing in the variety testing and registration process
- Support import of early generation starting material and/or tubers to boost seed volumes.

- Research options for government to subsidize private seed growers in the production of certified seed
- Develop/introduce climate resilient varieties for production in the hot lowland under rain fed and irrigated conditions
- Promote officially released potato varieties that are high yielding, resistant to diseases and suitable for various utilization demands
- Develop models for PPP to strengthen seed potato production, certification, storage and sale with county governments, donors, and seed companies
- Promote adoption of digital seed inspection and certification schemes
- Establish aggregation and logistics platforms to reach farmers with seed at the farm gate at lower costs

Way Forward

- Low-cost technology development for rapid production of quality planting materials
- Tissue Culture based seed potato Production (Meristem culture, single node cuttings, soil less culture and apical rooted cuttings)
- Domain base/low cost seed potato technology development (From PBS to BS3)
- Enthusiastic involvement of cooperatives, community and private sector in seed potato Production and distribution.
- Development of variety for short maturity (70-90 days), Longer dormancy, processing quality, disease resistance, resilient to climate change effects etc
- Utilization of biotechnological tools for crop improvement (molecular characterization, DNA finger printing, protoplast culture, anther culture, mutation Breeding and genetic transformation, etc.)
- Collection, characterization, evaluation, and maintenance of germplasm of underutilized tuber crops (Yam, Taro, Githa, Cassava, etc.)

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