

Strategies for Development of SUSTAINABLE SEED SYSTEMS IN TROPICAL TUBER CROPS



भाकृअनुप- केंद्रीय कंद फसल अनुसंधान संस्थान

(भारतीय कृषि अनुसंधान परिषद्)

श्रीकार्यम, तिरुवनंतपुरम 695017, केरल, भारत

ICAR-CENTRAL TUBER CROPS RESEARCH INSTITUTE

(Indian Council of Agricultural Research)

Sreekariyam, Thiruvananthapuram - 695 017, Kerala, India



TB-109/2025

Strategies for Development of SUSTAINABLE SEED SYSTEMS IN TROPICAL TUBER CROPS



भाकृअनुप-केंद्रीय कंद फसल अनुसंधान संस्थान
(भारतीय कृषि अनुसंधान परिषद)

श्रीकारियम, तिरुवनन्तपुरम - 695 017, केरल, भारत

ICAR-Central Tuber Crops Research Institute

(Indian Council of Agricultural Research)

Sreekariyam, Thiruvananthapuram 695 017, Kerala, India





Scheduled Caste Sub Plan 2025-26

ICAR-Central Tuber Crops Research Institute

Sreekariyam, Thiruvananthapuram 695 017

Kerala, India

Tel.No. : (91) (471) 2598551 to 2598554

E-mail: director.ctcri@icar.in

Website: <https://www.ctcri.org>

Published by

Dr. G. Byju

Director

Compiled and edited by

Dr. K. Sunilkumar

Dr. G.Suja

Dr. Visalakshi Chandra C.

June 2025

Correct Citation

Sunilkumar, K. Suja, G. Visalakshi Chandra C.2025. Strategies for development of sustainable seed systems in tropical tuber crops, Technical Bulletin No.109/2025, ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram 695 017, Kerala, India, 60 p.

© **Copyright:** No part of this publication may be reproduced without prior permission of the Director, ICAR-CTCRI, Thiruvananthapuram, Kerala, India

Contents

Title	Page No.
1.From the Director	01
1. Introduction.....	03
2. Over view of seed systems in tuberous vegetables with special emphasis on potato..	08
3. Over view of seed system in tropical tuber crops.....	11
4. Seed system in potato.....	16
5. Seed system in elephant foot yam	19
6. Seed system in sweet potato.....	20
7. Seed system in fruit crops.....	27
8. Seed system in ornamental crops	29
9. Towards sustainable seed systems in spices: technical and policy insights	34
10.Decentralized seed multiplier and seed village concepts in tuber crops	40
11. Seed certification standards in tropical tuber crops	44
22. Summary and recommendations	58



Dr. G. Byju
Director

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

From the Director



From the director

Tropical tuber crops are the third most important food crops which contribute to food and nutritional security, income generation, employment, source of feed and provide raw materials for many industrial products. These crops are cultivated in an area of about 0.40 million ha with a total production of about 8.74 million tons contributing to 4.64% of the total vegetable production in India.

The ICAR-CTCRI is the only research organization in the world dedicated solely to basic, strategic and applied research on 15 tropical root and tuber crops for catering to the needs of marginalized and tribal farmers as well as other stakeholders across the country. The Institute has made significant contributions through systematic research and extension programmes during the last sixty two years of service to the nation. ICAR-CTCRI has so far released 77 improved varieties of various crops with feature like high yield, disease resistance, biofortified varieties, industrial varieties etc. However, the spread of these varieties among stakeholders is hampered mainly due to shortage of planting material. In order to find solution to the perennial problem of planting material shortage in tropical tuber crops in the country, a 'National brainstorming workshop on formalization of seed system of tropical tuber crops' was organized on 03.12.2024 in hybrid mode.

Suggestions of the workshop include development and strengthening of a formal seed system for enabling faster spread of tuber crop varieties with a view to increase area from the existing 4.5 lakh ha to 5-6 lakh ha (10-30 percent) by 2030. ICAR-CTCRI has conceived the idea of seed villages and decentralized seed multipliers of tuber crops for enhancing availability of planting material and spread of the varieties. The same is being aggressively pursued under the Scheduled Caste Sub Plan scheme of the institute. For the benefit of SC farmers and other stakeholders of tuber crops, this technical bulletin is being published incorporating various suggestions and actionable recommendations resulted from the workshop.

I take pride in publishing the “Strategies for development of sustainable seed systems in tropical tuber crops' in the form of a technical bulletin which is could be adopted by various stakeholders for achieving self sufficiency in planting material availability. I am sure that this technical bulletin will be a useful and handy reference material to the researchers, development professionals, FPOs, seed entrepreneurs, farmers, SHGs and other stakeholders for their utilization and scientific adoption of quality planting material production in tropical tuber crops as well as similar vegetatively propagated crops. I appreciate the editors for their efforts in bringing out this publication in order to establish and strengthen al important aspects of a sustainable seed system in tropical tuber crops.

27.6.2025



G. Byju

1. INTRODUCTION

Tropical tuber crops occupy third position among staple food crops after cereals and pulses. Major tropical tuber crops include cassava, sweet potato, elephant foot yam, yams, taro, tannia etc. they are food security crops and cheap source of energy. They are climate resilient and could perform reasonably well under poor soil and management condition. Hence, it is suitable for cultivation by small and marginal farmers for their livelihood and also large scale cultivation for industrial purposes. Further, the biofortified varieties developed are able to combat malnutrition as well as protective food against cancer like disorder.

Non-availability of sufficient quantity seed/planting material with assured quality is one of the major problems faced by tropical tuber crops sector. Unlike the case of seed propagated crops, tuber crops seed system have certain inherent limitations with respect to ensuring required quantity and quality of planting materials on regular basis.

- a) Tuber crops are vegetatively propagated and have low multiplication rate of 5-7 times against 100 times or more in case of grain crops.
- b) Bulkiness and hence storage as well as transportation becomes difficult and costly. For example in case of elephant foot yam the seed rate is 7.5 t/ha which incur huge cost (40-50% of total cost of cultivation) for material and transportation.
- c) Since tuber crops are vegetatively propagated and perishable in nature, the seed material cannot be stored and need to be produced every season.
- d) Seed system of tropical tuber crops is predominantly dependent on public sector agencies and seems less attractive to private players in terms of economics.

Because of the above, only a small portion of entire seed requirement by this sector is currently met and need a different approach to tackle the issue.

Being the national institute working on tropical tuber crops and nodal agency for its seed system, ICAR-CTCRI proposes to address the same in a proactive manner.

Hence, an intervention for development of seed system in tropical tuber crops is proposed to be implemented. This is envisaged to be achieved by integration of existing formal (public sector) and informal (Farmer groups, FPOs, SHG, NGO etc) seed producers in one hand and identifying and promoting new local seed producers (Decentralized Seed Multipliers-DSM) on the other. The DSM model is already implemented in Kerala and Tamil Nadu, where seed production is done locally through designated Decentralized Seed Multipliers and found successful. It is

expected that by this way the lack of institutional capacity, lack of implementation mechanism and the lack of seed standards in the ground could be addressed to a great extent.

Thus, in order to discuss and find solution to the perennial problem of planting material shortage in tropical tuber crops in the country, the 'National brainstorming workshop on formalization of seed system of tropical tuber crops' was organized on 03.12.2024 in hybrid mode. It was attended by 239 participants both online and offline across the country including the AICRP-TC Centres.

The workshop was intended to develop a formal seed system for enabling faster spread of tuber crop varieties with a view to increase area from the existing 4.5 lakh ha to 5-6 lakh ha (10-30 percent) by 2030. It was attended by DDG (Hort.), ADG, former and present directors, national experts and distinguished scientists working on vegetatively propagated horticultural crops from across the country.

The following is the list of dignitaries and panelists of the workshop

- **Dr. Sanjay Kumar Singh**, Deputy Director General (Hort. Sci.), ICAR, New Delhi
- **Dr. Sudhakar Pandey**, Asst. Director General (Hort. Sci.), ICAR, New Delhi
- **Dr. S.K. Chakrabarti** Former Vice Chancellor, UBKV West Bengal and former Director, ICAR-CPRI and ICAR-CTCRI
- **Dr. G. Byju**, Director, ICAR-CTCRI, Thiruvananthapuram
- **Dr. James George** Former Director, ICAR-CTCRI and Project Coordinator, AICRP-TC
- **Dr. M. Nedunchezhiyan**, Principal Scientist, ICAR-CTCRI- RC, Bhubaneswar
- **Dr. Vinod Kumar**, Head of Division, Crop Improvement and Seed systems, ICAR-CPRI, Shimla
- **Dr. M. Sankaran**, Head of Division, Division of Fruits, ICAR-IIHR, Bengaluru
- **Dr. P. Naveen Kumar**, Head of Division, Division of Floriculture, ICAR-IIHR, Bengaluru
- **Dr. Jayanta Tarafdar**, Former Director of Research, Bidhan Chandra Krishi Viswavidyalaya, Former o/i, ICAR-AICRP on Tuber Crops, BCKV, Mohanpur 741252 (WB)
- **Dr. K. Sunilkumar**, Principal Scientist, ICAR-CTCRI, Thiruvananthapuram
- **Dr. R. Muthuraj**, Principal Scientist, ICAR-CTCRI, , Thiruvananthapuram
- **Dr. Lijo Thomas**, Senior Scientist, ICAR-IISR, Kozhokode

Dr. K. Sunilkumar briefed about the context of the workshop and welcomed the dignitaries as well as participants offline and online. Dr. G. Byju, Director, ICAR-CTCRI in his opening

remarks stressed the importance of tuber crops in sustainable food system and its climate resilient nature. He exhorted the need for making available quality planting material in these food security crops and the efforts being taken up by the institute in this direction are outlined. Further, he welcomed the DDG, ADG and other dignitaries to the workshop. Dr James George, Former Director ICAR-CTCRI and Project Coordinator, AICRP-TC described the earlier efforts at CTCRI during his period and described how the institute has progressed in development of a sound seed system and expressed his best wishes for the workshop. He suggested to aggressively follow up the seed village programme for spread of many improved varieties the institute has recently developed.

Subsequently, Dr. S.K. Chakrabarti, Former Vice Chancellor UBKV, West Bengal and Director ICAR-CPRI and ICAR-CTCRI has described the tropical tuber crops as a wonderful group of crops that are resilient to climate adversities. According to him tuber crops can give yield even in marginal/degraded soils. Area expansion is mainly hampered by lack of quality planting material. Further, due to vegetative propagation nature of tuber crops, virus and nematodes often accumulate and seed degeneration is very common. Use of quality planting material of improved varieties alone can ensure 20-25% yield increase and it can be further increased to 40-45% through optimal use of other inputs and management options. Hence, quality seed material is utmost important. Formal seed system of cereals/grains has greatly contributed to green revolution in the country. At national level, about 9400 varieties of 190 crops are being produced and distributed through Seeds Division of Govt. of India. Major development in formal seed system happened mainly in cereals and in vegetable that are propagated through seeds. However, vegetatively propagated horticultural crops didn't get much importance in formal seed system and the development of the same is very slow. Formal seed system consists of two parts a. Technological system and b. Production system. ICAR-CTCRI having developed and released 77 improved varieties has partly fulfilled the technological requirement for a formal seed system and the main thrust must be to establish seed production system that ensures multiplication to scales so as to establish a formal seed system. For this modern multiplication technique developed at CTCRI or elsewhere should find a place in Blue Book. Presently cassava planting material means 20cm long cutting or sett and in taro 20-40g corm are only considered as seed material. Attempts should be made to incorporate novel techniques available now with the help/guidance of SMD at national level. It's necessary to describe testing and validation procedures that are to be followed and also establish a formal centre of quality checking (testing). Efforts must be taken to ensure documentaion of minimum seed standards for all major crops being dealt by CTCRI and also need to develop the same in crops where it is not available at present.

In a formal seed system the seed system starts with respective state governments preparing a seed rolling plan. According to this plan, indents will be raised and send to Seeds Division of Ministry of Agriculture, GOI, which in turn direct the indents to potential seed producers/suppliers. Even though cassava is an important industrial crop in Tamil Nadu, it does not find a place in Seed Rolling Plan (SRP) of Tamil Nadu. Also, sweet potato does not find a place in SRP of Odisha. Only West Bengal has SRP for elephant foot yam. Further, the plan describes traits of notified varieties, regions of seed production etc. If we know the seed rolling plan of various states, we will know the requirement of certified seed for particular state for particular year/season. Based on the quantity of certified seed requirement one can back calculate to arrive at quantity of breeder seed requirement and then to nucleus seed required. To establish formal seed system, first tuber crops to be included in seed rolling plan in state, where they are cultivated in considerable areas. Then the requirement/indent will originate and will be reaching the breeder/certified producers as the case may be.

As the involvement of private sector is not significant as of now, it was suggested to ensure participation of state governments, NGOs, FPOs, SHGs etc in seed multiplication process. Hence, develop a feasible model specific to these group of tuber crops by integrating formal and informal systems/models.

Dr. Sudhakar Pandey, Asst. Director General (Hort. Sci.), ICAR, New Delhi in his address stressed the importance of ensuring QPM as there is huge demand existing. According to him, even though crops like elephant foot yam is highly remunerative with very good BC ratio, farmers are abandoning cultivation due to high volume and low storage life of seed material. Hence, efforts must be made to map potential areas for seed production in the major growing states (traditional) and also in North-Eastern hills region (non-traditional), which offers great potential for cultivation of tubers. He stressed the need to develop minimum seed certification standards for each category of seeds and ensure their entry in Blue book which is essential in formalizing the seed system of any crop. Further research may be strengthened to further reduce seed size/volume.

Hon'ble **Dr. Sanjay Kumar Singh**, Deputy Director General (Hort. Sci.), ICAR, New Delhi inaugurated the workshop. In his inaugural address, he pointed out that tuber crops are very much part of tradition, culture and also component in homestead farms. The planting material of vegetatively propagated crops has been a weakest point in horticultural sector which include perennial horticulture crops as well as tuber crops group. We could take cue from banana seed system, which has shown the way where the movement of suckers across state/national border is virtually stopped and only tissue culture plants are allowed across borders. In case of tuber crops, the strong network of AICRP may be leveraged for strengthening seed system, which the Director and PC may look upon. He mentioned the success of potato seed system especially with

cutting edge aeroponics technology, which has revolutionized seed system. Seed system of potato under ICAR-CPRI is perhaps the biggest seed production system of the crop in the world. In line with that, seed material may be supplied for multiplication by seed producers and buy back may be ensured. As far as tuber crops are concerned, participatory seed multiplication (like DSM) will be a viable option for ensuring availability of quality planting material. For other crops, Department of Biotechnology is doing the virus indexing for seed certification. He also referred the clean plant programme (CPP) of Govt of India for the perennial fruit crops as an encouraging step in this direction. Also we have to be cautious of rampant import of vegetative materials through Open General Licence and the like by which spread of pests and diseases especially virus diseases. Hence, development of indigenous seed system in vegetatively propagated crops is need of the hour so as to meet the fast growing demand.

The inaugural session came to an end with vote of thanks by Dr. Visalaski Chandra C., Senior Scientist, ICAR-CTCRI and coordinator of the workshop.

Technical session was chaired by Dr. S.K. Chakrabarti, Former Vice Chancellor, UBKV West Bengal and former Director, ICAR-CPRI and ICAR-CTCRI and co chaired jointly by Dr. G. Byju, Director, ICAR-CTCRI, Thiruvananthapuram and Dr. James George Former Director, ICAR-CTCRI and Project Coordinator, AICRP-TC. The session consisted of 10 theme papers mostly in tropical tuber crops and in other vegetatively propagated crops such as potato, fruits, ornamental crops and spices from which gave important insights for strengthening of the seed system in tropical tuber crops.

2. OVER VIEW OF SEED SYSTEMS IN TUBEROUS VEGETABLES WITH SPECIAL EMPHASIS ON POTATO

Dr. S.K. Chakrabarti

Former Vice Chancellor, UBKV West Bengal and former Director, ICAR-CPRI and ICAR-CTCRI

The seed system of potato is applicable to most of the tropical tuber crops and hence detailed understanding of the already developed potato seed system will help in the development of a formal seed system in tropical tuber crops also. Potato is propagated through botanical seeds, tubers and microplants (tissue culture plants). Of this major planting material is tubers and the same account for 40-50% of production cost. In case of true potato seed propagation, the problem of lateness and heterogeneity often becomes limitations to use it on commercial scale. Also high production cost is a limitation due to strict quality control protocols. The seed multiplication ratio in conventional method is 1:6 which is similar to most of the tropical tubers. However, with development of aeroponics propagation technology, multiplication rate of 1:40 to 80 could be achieved.

For any seed system, one should be aware of the strength and weaknesses of seed material and procedures of its production. In case of potato, the seed rate is 2.5-3 t/ha which works out to 18 lakhs MT of certified seed for planting the estimated area of 2.18 million ha with a seed replacement ratio (SRR) of 33%. Out of this 5 lakh is being produced through formal system through conventional methods. About 12 lakh MT is being produced by the private sector. Seed Rolling Plan of West Bengal (which produces 1/5th of countries potatoes) for 2024-25 indicates a requirement of 3.5 lakh MT with a SRR of 38% and in Punjab 1.27 lakh MT and SRR expected is between 25 and 50%. Small and marginal farmers do not save seed material from their production, but purchase from Jalandhar in Punjab or from Western UP. There is robust seed system in place for potato under formal sector with ICAR-CPRI and Seeds Division, GOI playing the key roles. Breeder seed supplied by ICAR-CPRI. Foundation seed by national seeds corporation (NSC) or state seed corporations (SSCs). The nucleus stock is TC plants. The requirement of foundation seed/breeder seed/nucleus seeds are arrived at by back calculating from the requirement for certified seed as per Seed Rolling Plans of all states together. As of now the seed being supplied by private sector is not certified but only truthfully labeled (TFL) seeds and they are not agreeing to the demand for certification citing the costs involved and the present number of generations permitted in field is not economical.

In the formal potato seed system, DBT is the responsible agency to certify that the material is free from virus (virus indexing) for mother stock maintained by ICAR-CPRI and the same is supplied to various TC labs for further multiplication/distribution. In case of potato the stages of seed multiplication and classes of seed are as follows:

Certification Agency	Stage	Classification of seed	Protocol/Reference
DA & FW, ICAR-CPRI	Stage I-Ist year	Nucleus seed	Chapter 8, Seed Potato Production Techniques: Principles and Applications, Technical Bulletin p105
	Stage II-2nd year	Pre breeder seed	
	Stage III-3rd year		
	Stage IV- (4th year)	Breeder seed	
State seed certification agency	Foundation seed-I (5 th year)	Foundation seed	Chapter XV, Indian Minimum Seed Certification Standards, GOI, New Delhi
	Foundation seed-II (6 th year)		
	Certified (7 th year)	Certified seed	

The following are the routes of potato seed multiplication at present

1. Micro plant-micro tuber-minituber system
2. Micro plant-minituber system
3. Aeroponics-minituber system
4. Apical rooted cutting method-Minituber

In the first system the limitation is the rate of establishment i.e. only 50-60%. In case of second method upto 80-90% establishment possible. However, handling of TC plants especially during transport is a problem. In case of aeroponics technology, the rate of multiplication is faster i.e. 35-60 minitubers per plant and is of high quality as field exposure is limited. Here, the tubers produced is 7-10 times higher by way of multiple picking of minitubers of desired size. The technology is customizable as per the local conditions. In case of apical rooted cuttings, cost is reduced to 1/10th as that of aeroponics method where the apical dominance is being exploited, by cutting apical meristem and stimulating auxillary stems to grow to produce multiple shoots which are then cut and rooted in protray with suitable media. Once rooted, transplanted to field to produce seed tubers.

Definition of TC raised breeder seed is as follows:

Microplants /microtubers are considered as nucleus seed. Potato tissue culture raised minituber (PTCMT) under net house or aeroponics system is the breeder seed (G₀). This is followed by Field generation-1 (Foundation 1), Field generation 2 (foundation 2) and field generation 3 (certified) seed. For potato seed multiplication, the same field is not allowed for second year for seed multiplication. Presently ICAR proposed two seed systems for certification such as via aeroponics method and through apical rooted cutting (ARC) method.

Successful potato seed system in other countries also was discussed. The Netherland has got a very strong seed system for potato which consists of 10 stages (G₀ to G₉) stages from pre basic

seed to certified seed which result in much higher rate of multiplication. However, the stringent quality control is followed through the national seed certification agency (NAK). The Scotland also has got strong seed system for potato which allows upto 7 stages/years of multiplication and the certification agency is SASA.

Future strategies for strengthening potato seed system

- Large scale integration of conventional and innovative techniques for seed multiplication
- Promotion of seed village concept
- Engaging progressive farmers and private players in seed multiplication
- Discontinuation of seed production in disease affected plots
- Adoption of aeroponics technology or ARC technique for minituber production
- Adoption of diploid true potato seed (TPS) technology



Acropnics in Potato for Clean Seed Production

3. OVER VIEW OF SEED SYSTEM IN TROPICAL TUBER CROPS

Dr. James George

Former Director (A), ICAR-CTCRI and Project Coordinator, AICRP-TC

The major limitations of tuber crops seed production system are as follows

- Seed degeneration: farmers use locally available material which may be often infested.
- Low genetic diversity: improved varieties need to be popularised
- Poor seed quality: enough care not taken while handling, by which lot of damage occurs to planting material and thereby loss of materials
- Limited access to improved varieties: ICAR-CTCRI has done remarkably well in development of varieties, which counts to 77. However, the availability of desired quantity of seed material is still a limiting factor which needs attention.
- Lack of formal seed system :Informal seed network is common where farmer to farmer exchange is predominant

Ways to overcome the present situation are

- Multiplication of enough basic material/nucleus material at ICAR-CTCRI
- Leveraging semiformal systems for seed multiplication
- Farmers training programmes to create awareness on importance of QPM and encouragement to go for clean seed material once in 3-4 years
- Adoption of community based seed multiplication systems
- The potato seed system model could be implemented in some of the crops where it fits
- Incorporate various innovative methods presently available for seed multiplication

Cassava

Selection of planting material: Traditionally, cassava is propagated vegetatively through stem cuttings, usually called 'setts' or 'stakes', taken from the previous season crop and so the stems are often to be stored for two to three months. Fresh stakes from mature plants can also be used. Storing the stakes for a period of 15 days has been observed to give maximum sprouting (96%) as compared to planting fresh stakes (90%). Stems kept in vertical position give better sprouting as compared to those in horizontal position. Further, storing stems beyond 60 days result in loss of viability with lower sprouting of 14- 75%. One practical way of knowing whether a stem is sufficiently mature is to determine the relationship between the diameter of the pith and stem cuttings. In a transversal cut, if the diameter of the pith is equal or little less than 50% of the

diameter of the stem, it is sufficiently mature to be used for planting. Planting material from plants of 7-10 months maturity, free of pests and diseases, with a stem diameter of 2-3 cm is recommended.

Preparation of setts: Setts are prepared by discarding 1/3 of the total length of the stem from the top and about 5 cm from the bottom. A sett length of 15-20 cm with 10-12 buds are ideal for planting. Smooth circular cut is preferred for preparing the setts rather than an irregular cut for uniform callus formation and tuber initiation

Minisett technique

Cut stem pieces of two nodes is optimum to be used as minisetts for rapid production of planting material in cassava. Minisetts are planted in nursery beds in shade net house. A nursery area of 45 sq.m is required for producing minisetts for planting one hectare of main field. Furrows of 5 cm depth are made across the width of the bed with a khurpi or small hand hoe. Two node cuttings are then planted in the furrow, end to end horizontally, at a spacing of 5 cm. The minisetts would start sprouting in a week time. The minisetts will be ready for transplanting in the main field after 3-4 weeks. Two to three fully opened leaf stage is the optimum time for transplanting. Multiplication ratio using minisett technique is 1:60 instead of 1:10 in the conventional system.

Tissue culture could be a viable option upto nucleus seed or initial generation of pre basic seed where upto 15000-20000 plants could be produced from a single plant. However, there was less survival percent encountered. Hence, perfection of hardening protocol in case of TC multiplication of cassava is essential to ensure maximum survival percent. Minisett technique of cassava with two nodes was suggested as a feasible option for rapid multiplication where in 1:10 could be increased to 1:60. There is a need to develop a customized transport system for minisett plants as well as TC plants to prevent loss during transit. Also, regular seed replacement at every 3-4 years may be ensured to avoid seed degeneration.

Taro/Tannia

In taro the rate of multiplication is very good in conventional method and the minisett technique may not be needed in normal case.

Sprouted corms and suckers are used in propagating tannia and are reported to give higher yields than the tubers. Damaged corms and planting material showing signs of decay should be discarded. Planting material should only be taken from healthy and vigorous plants. Disease-free planting material could now be produced by tissue culture, which results in even higher multiplication rate. Healthy cormels of 50-100 g weight and 20-25 cm length and corms weighting 150-200 g size are ideal as planting material. For planting one hectare 1.8-2.5 tons of

corms or 0.6-1.0 tons of cormels are required. Usually the seed materials are planted 6-7 cm deep. While planting the cut pieces of the main corm or suckers, it is advisable to keep the apical portion above ground level.

In tannia minisett technique is essential because of low multiplication rate and high volume. In the minisett technique, mother corms are selected from healthy plants at harvest. Such mother corms are first cut into cylindrical pieces and then cut radially to prepare minisett of about 15 g weight. If minisett are raised in a nursery, they could be transplanted in a month to the prepared main field. A major advantage of adopting minisett technique in tannia is that the cormels which are the economic part of the crop can be fully marketed. Corms which are less-edible would be used for minisett multiplication.

Yams

Propagation and planting materials : Yams are propagated vegetatively through either small whole tubers or tuber pieces. The whole yam of one kg weight is considered as seed yam. The seed yams are cut into setts (small pieces) while small tubers are planted as such. The small whole tubers or seed yams are preferred for their earliness and uniformity in sprouting. The average weight of 200-250 g tuber/sett is optimum for the cultivation of *D. alata* and *D. rotundata* whereas 100-125 g is ideal for *D. esculenta*. In storage condition, yam tubers remain dormant for about 2 months, hence quick dipping in 4-8% solution of ethylene chlorohydrin followed by dry storage is practised to break the dormancy. Yam can also be propagated through vine cuttings as it is a very useful technique for rapid multiplication of desirable clonal material, but tuber production by this method is slow.

Seed yam production through minisett technique: A major hindrance in the popularization of high yielding varieties is its very low multiplication rate. Traditionally yam is cultivated by making setts of 200-250 g from mother seed yam. From 1 kg mother seed yam only 4-5 setts could be obtained limiting the multiplication ratio to just 1:4-5. This low multiplication ratio implies high cost of planting materials, long time required for multiplying sufficient planting materials, difficulty in transportation, low availability of quality planting materials in improved varieties. Seed yam (1 kg weight) can be produced through minisett technique by reducing the weight of planting material to 30 g, a multiplication ratio of 1:24-30 could be obtained from one kg of seed yam after considering waste and damages. Even by reducing the weight of planting material to 30 g minisett, the yam still has the capability to sprout, because buds are spread all over the periderm (skin surface) of yam tuber. Hence, retaining and protecting periderm in each piece of tuber/sett is essential. Yam tuber, by nature has apical dominance; however, when they are cut into small size, the dormant buds get activated and would eventually sprout, subject to the

availability of congenial environment. Hence, any portion of yam tuber with periderm is capable of sprouting and producing a new plant. Further, once the roots are produced from a yam tuber, the physiological system governing the growth of the crop would prompt the root to draw nutrients from the soils and not from the seed material. As a matter of fact, the size of the seed material is immaterial as far as sprouting of a yam tuber is concerned.

Preparation of minisetts: For preparing minisetts, the tuber is first cut into small cylindrical pieces of about 5 cm length. From these cylindrical pieces, minisetts of about 30 g weight is prepared. Treating the minisetts with the combination fungicide, Carbendazim + Mancozeb (2g /l) or cow dung slurry is very beneficial to the crop. Such treated minisetts should be spread out under shade for a day prior to planting. Planting in nursery. Minisetts are planted in the nursery in furrows made across the bed (soil-sand mixture in the ratio 1:1), 5 cm deep, with cut surface facing up. This helps to prevent drying up of the periderm. Spacing between two rows is 5 cm. After planting, they must be covered with a thin layer of soil/sand mixture. Light irrigation soon after planting followed by light intermittent irrigations till sprouting is preferable. Thereafter, as per need the nursery may be irrigated. The *D. alata* minisetts sprout within a fortnight and on reaching three to four leaves stage it becomes ready for transplanting. However, *D. rotundata* minisetts are found to take about a month for sprouting. It is therefore essential to adjust the nursery planting time in accordance with the onset of monsoon, if the crop is to be raised as rainfed. While *D. alata* nursery could be planted during first week of May, so as to transplant during the first week of June in Kerala, minisetts of *D. rotundata* could be planted in nursery during third week of April for subsequent transplanting in June. Transplanting yam minisetts. As mentioned above, transplanting should invariably be done after receipt of rains, on ensuring proper moisture content in the soil. After field preparation ridges are to be made, 60 cm apart. Sprouted minisetts are pulled out carefully using khurpi, without damaging the roots and are transplanted on the ridges, 45 cm apart, thus accommodating about 37,000 plants, while in the conventional planting (90 x 90 cm) 12,345 plants could be accommodated in a hectare. The minisetts establish in the field in about a weeks' time.

Storage of seed yams: It is advisable to give a healing time to the harvested seed yams prior to their storage, by spreading them under semi shade condition for a day. This helps in natural healing of all the little wounds on yam tubers so that they do not get rot while in storage. Yams can be stored in the open condition by tying on to live shade trees, which is a common practice in west African countries. Under Indian conditions, it is ideal to store yams on a rack, taking care that the tubers do not touch each other. These racks could be placed in a well-ventilated storage shed facilitating diffused light inside.

Arrowroot

An important crop for high value starch production and hence, quality planting material production is important to increase the area under cultivation especially for non traditional areas like NE region.

Arrowroot doesn't set seeds and normally propagates from small pieces of rhizomes 4-7 cm with 2-4 nodes on them known as bits. The 'bits' are sometimes treated with smoke to aid germination. Suckers are also used occasionally for propagation. If suckers are used, preparation of planting material should actually start at the time of harvest of the crop. Suckers are separated from the clump and planted 30-45 cm apart in the nursery during off season. These suckers give rise to new plants which are uprooted and the canopy cut off to retain 10 cm of the shoot intact with roots. Thus the planting material becomes ready. Plant two clumps at a distance of 45 cm. The requirement of planting material is about 3 t/ha which is quite high.

General suggestions

- Different methods may be integrated for rapid multiplication of quality planting materials in tuber crops. For example tissue culture-minisett-field multiplication
- There should be a dedicated seed production unit and a team should be designated exclusively for ensuring regular supply of clean seed material (nucleus/breeder/seeds as the case may be)
- ICAR-CTCRI may need to shoulder the responsibility of ensuring availability of base material of major tuber crops and their varieties



Minisett and protrait nursery for rapid multiplication in tuber crops

4. SEED SYSTEM IN POTATO

Dr. Vinod Kumar

Head of Division, Crop Improvement and Seed Systems
ICAR-Central Potato Research Institute, Shimla

In potato, for a 100 % seed replacement rate, the total seed requirement for an area of 2.18 million Ha will be 54 lakh MT annually. Formal system provides 10% of this and private players about 20% and hence, the present SRR is about 30%.

There are two seed systems in operation; one formal system comprising of ICAR-CPRI and Seeds Division, GOI. The informal system consists of private sector as well as the farmer to farmer exchange and there is reluctance by private players to adopt the formal system citing the complexity involved in the certification and labelling systems.

ICAR-CPRI method of seed production consists of both conventional and hitech methods. The conventional system is as follows:

70-80 plants will be selected in the field, and will under go singled out growing and four tubers per plant will be selected. In stage -1, clonal multiplication done in field at 1x1 m spacing. The plants are double ELISA tested (200%) and harvested individually.

In stage 2, clones are grown in separate rows at 1 x 0.2 m spacing, followed by 100% ELISA testing through composite and bulked samples

Stage 3, bulk multiplication at 0.6 x 0.2m spacing, 300 plants are ELISA tested per ha. Rogueing is followed.

Stage 4, breeder seed with 0.6 x 0.2m spacing with 150 plans ELISA tested per ha with rogueing. Breeder seed is further multiplied with increased spacing of 1m x 0.2m.

Hitech method of seed production has become necessary to enhance the rate of multiplication at the same time ensuring quality. Any of the following methods adopted in a hitech seed production system

- a. Microplant based seed production
- b. Microtuber based seed production
- c. Aeroponics based seed production
- d. Apical rooted cuttings (ARC) based seed production

For all these, first step is virus elimination with following procedures:

Clonal selection followed by ELISA test and then PCR test and healthy mother plant identified. The plant is then tissue cultured to produce enough microplants. In case of ARC, the tuber is

sprouted, sprout is tissue cultured to obtain microplant. This is virus tested and then multiplied in ARC method. The virus elimination is ensured by using mericlones for TC.

To make it free from virus, the following sequence is adopted:

Mother plant- shoot tip culture-virus test. If positive it is abandoned and if found negative (virus free) its subjected to thermo/chemotherapy, then meristem is collected-mericlones-virus test-TC of virus free material.

In microplant based production, the microplant is grown out in insect proof net house which usually has 80-90% survival and gives 8-12 minitubers/plant. It is further multiplied for two generations (G1 and G2) to produce breeder seed.

In microtuber based, plants subjected to TC by following all essential tests and then microtuber induced and harvested from flasks.

In aeroponics system, the advantages are

- a. Faster multiplication rate (tuber produced in half the time compared to field multiplication)
- b. Free from soil borne pathogens, nematode etc
- c. Cost effective after reaching 4 or 5 generations (G5)
- d. Saving of *in vitro* plants ie 100% survival ensured by this method
- e. Saves water and nutrients compared to soil system of multiplication
- f. Desired size and number of minitubers could be ordered (obtained) in such system

In this method, plants are washed and panted in styroform of aeroponic unit. In 35-40 days, stolon formation occurs and after 50 days first picking (harvest) could be taken and a total of 10 pickings possible from single crop. The mini tubers are cured for a week at 15-20°C and then stored at -4°C to avoid spoilage.

TPS method combined with aeroponics technology is adopted for speed breeding practices where the TPS sprouted seedlings are planted in aeroponics system for faster multiplication.

ARC system of seed production: here the time required is still less compared to aeroponics as the shoot tips of plants in net house is directly used for aeroponic cultivation skipping tissue culture stage.

ICAR-CPRI proposed the following system of seed production in potato

Stage	Seed classification	Remarks
Microplant / microtuber based	Prenucleus	
Minituber obtained through growing in aeroponics or insect proof net house(G0)	Nucleus	Could be completed in one year which takes two years in field /net house
Field generation-1(G1)	Pre breeder	
Field generation-2(G2)	Breeder seed	
Field generation-3(G3)	Foundations seed-1	
Field generation-4(G4)	Foundations seed-2	
Field generation-5(G5)	Certified seed	

In short, the advantages of aeroponics technology is as follows:

- Seed production through hitech system (aeroponics) will improve seed quality and speed up multiplication
- The system can reduce the number of field exposure and hence clean seed material possible
- It can shorten the time gap between variety release and supply of seed to farmers for cultivation
- It can increase volume of production and reduce the production costs

5. SEED SYSTEM IN ELEPHANT FOOT YAM

Dr. Jayanta Tarafdar

Former Director of Research, Bidhan Chandra Krishi Viswavidyalaya,
Former o/i, ICAR-AICRP on Tuber Crops, BCKV, Mohanpur 741252 (WB)

Seed system of elephant foot yam, the king of tuber crops (Ravi *et al.*, 2009), was deliberated under this session. Major varieties include Gajendra, Sree Padma, Sree Athira, Kovvur and Bidan Kusum. It's a highly remunerative crop and the demand for planting material is huge. However, the hurdles in seed production are high volume, long crop duration as well as poor shelf life and storage facilities. The area under cultivation west Bengal is 11.266 thousand ha with production of 360.74 thousand MT and productivity of 32t/ha. Major states of cultivation are West Bengal, Bihar and Andhra Pradesh. Of this West Bengal is the leader in production. But seed production is not done in West Bengal and the seed materials are mainly brought from Bihar and Andhra Pradesh. Recently farmers are using lesser sized seed corms and optimum size of seed corm is 500 g.

Constraints include, the farmers are least interested to retain seeds, high post harvest loss, long crop duration, absence of a well organized seed system and market, lack of storage facility for seed material, intensive cropping system being followed in the state due to which farmers can't afford to wait upto 9 months for seed use and are harvested early for vegetable purpose for which bigger corms (6-8kg) are preferred. Further, the pseudostem is also sold for vegetable purpose. This also leads to early harvest of the crops before the periderm development happens. Huge loss of produce is faced many a time during transport by rot, respiration and moisture loss.

By adoption of reduced seed size, the seed requirement, spacing/land requirement etc could be reduced and thereby cost of production. Miniset of 200 g size is enough to obtain one kg seed corm with 50x50cm spacing. The multiplication could be accelerated by utilizing the eyes/side corms. They are scouped and sprouted in cocopeat+sand media which can produce mini corms which in turn produce seed corms. Its cheaper method compared to tissue culture although, the rate of multiplication may vary depending on the number of eyes available.

Major threats faced by the crop are collar rot in field and corm rot during storage.

Way forward

- Rapid multiplication and ensuring availability of enough seed material for elite varieties
- Supply of high quality base material (nucleus/breeder seed)
- Awareness on miniset method
- Timely supply of quality planting material
- Establishment of seed village or community based/participatory seed production approach
- High density planting
- Mini/micro corm production
- Its desirable to have at least one seed village in every district where the crop is cultivated in considerable area

6. SEED SYSTEM IN SWEET POTATO

M. Nedunchezhiyan*, K.H. Gowda, K. Pati, R. Arutselvan and S.K. Jata

¹Regional Centre, ICAR-Central Tuber Crops Research Institute, Bhubaneswar – 751019, India

*Email: m.nedunchezhiyan@icar.gov.in; mnedun@gmail.com

Introduction

Sweet potato is an important root crop in tropical and sub tropical countries. Among the root and tuber crops grown in the world, sweet potato ranks second after cassava. The carbohydrate rich root is used as a subsidiary food after boiling/baking. Vines form an excellent source of green fodder for cattle. Development of varieties having high dry matter, starch, carotene and anthocyanin has opened up new vistas in industrial applications apart from traditional usage as food and feed. Industrial products like starch, liquid glucose, citric acid, mono-sodium glutamate and ethanol are produced from sweet potato roots in various countries. The biomass and byproducts of sweet potato can be effectively converted into high value vermicompost (Nedunchezhiyan et al., 2011).

Sweet potato easily adapted to wide range of edaphic and agro-climatic conditions. It has capability to mitigate mid season drought. The economic part being in under-ground, the crop rejuvenates its growth once favourable condition is prevailed. In India, government of Odisha has included sweet potato in all crop diversification programmes especially operated in drought prone areas (Nedunchezhiyan et al. 2006; Lenka et al. 2012). Sweet potato produces high amount of energy per unit area per unit time and is expected to bridge the food shortages and malnutrition. The comparative short duration coupled with its innate power for tremendous dry matter production has enabled sweet potato to rank as the foremost root crop in respect of calorie value. It has the potential as a feedstock for bio-ethanol production.

However, availability of quality planting material is the major constraints in sweet potato cultivation. Sweet potato being vegetatively propagated crop requires huge quantity of vine cuttings for planting per unit area in compared to sexually propagated crops like cereals, millets and pulses. For planting sweet potato in one ha requires 83000 vine cuttings (20-25 cm length each) i.e. 16000-20000 running meter/ 1000 kg weight/ 4 m³ volume. Sweet potato is a four months crop. Rainfed farmers for planting in next season, needs to maintain nursery 8 months. Irrigating the sweet potato nursery during summer is difficult due to lack of water. Hence, the traditional farmers make small nursery in the backyard. Further, transportation of such voluminous quantity of planting materials to the field is also a big problem. In spite of many constraints, the sweet potato cultivation is continuing in traditional areas, because of suitability of sweet potato to the climate and soil of the particular region.

are planted in the secondary nursery at a spacing of 20 cm within ridges. To ensure enough vegetative growth 5 kg of urea is applied in two splits at 15 and 30 DAP. For the better establishment of vines in nursery irrigations are provided at every alternate day for the first 10 days and thrice in a week thereafter. The vines will be ready for planting in the main field after 45 days.

In vitro production of tissue culture plantlets can also be maintained in nursery after proper hardening. These in vitro generated planting materials are mostly free from virus. Vines from tissue culture plantlets produce uniform plant growth. Planting material production through tissue culture method is suggested for once in five years to prevent virus diseases.

Variety

In sweet potato, the variety plays a significant role in yield improvement. In many Research and Development organizations working on sweet potato have the major objective of developing location specific sweet potato varieties.

Orange Flesh Sweet Potato

Normally sweet potato flesh colour is white, but some of the cultivars have purple, yellow and orange flesh. The orange flesh sweet potato contains β -carotene which is a precursor of vitamin A.

The orange flesh sweet potato varieties/genotypes that are cultivated in India are Bhu Sona, Kamala Sundari, Sree Kanaka etc.

Purple Flesh Sweet Potato

Purple flesh sweet potatoes have purple colour in the flesh of the storage root due to the accumulation of anthocyanins. Anthocyanins have applications in pharmaceutical and cosmetic industries due to its bright colour, non-poisonous nature, rich nutrition, safe and health care function. The Regional Centre, ICAR-Central Tuber Crops Research Institute (CTCRI), Bhubaneswar (India) has developed a high anthocyanin variety Bhu Krishna.

Climate And Soil

Sweet potato requires moderate temperature (21-26°C); hence it is planted and harvested every month in one part or other in the world. A well distributed rainfall of 75-150 cm is sufficient for its cultivation. Well drained loam and clay loam soils are good for sweet potato cultivation. Sweet potato is mostly grown in acidic soils, however soil pH 5.5-6.5 is found optimum.

Time Of Planting

Time of planting has been identified as one of the most important factors affecting growth, yield and quality of roots (Nedunchezhiyan and Byju 2005). In India, sweet potato is grown throughout the country, utilizing monsoon rain during *kharif*, (June-August), and with supplemental irrigation during *rabi* (October-December).

Preparation Of Planting Materials

Vine portion and length of cutting

Sweet potato root yield could be improved the use of good planting materials. The apical and middle portion of the vine is found to be the best planting material for getting higher root yield. Bottom portions, usually thick and woody, some times fail to establish and there is greater chance of weevil incidence due to proximity with the crown portion, where sweet potato weevil multiplies. A vine length of 20-40 cm with at least 3-5 nodes is found to be optimum for the storage root production.

Preparation of vines

Cut vines with intact leaves are stored under shade for two days prior to planting in the main field to promote better root initiation, easy establishment of vines and higher root yield. Storing of vines for a long time caused failure of establishment in the field due to drying. The leaves of the vines can be removed when the vines are to be transported to distant places to reduce the bulkiness. This method can be adopted for multiplication of planting materials which involve transportation costs.

Land Preparation

The land is ploughed or dug to a depth of about 20 cm and harrowed to pulverize the soil. Mound method, ridge and furrow method, bed method and flat method are practiced in sweet potato cultivation in different localities. It is preferable to plant sweet potato on mounds in areas experiencing problems of drainage. In sloppy lands, ridge and furrow system is recommended for the control of soil erosion.

Planting

Sweet potato cuttings are normally planted in the soil with both ends exposed and the middle portion buried in the soil. Vines are also planted in an inclined position with half of its length buried in the soil. Sweet potato cuttings were also planted horizontally to the soil surface with 5 or 6 nodes. Horizontal planting resulted in higher transplant survival and better development of the root system than other methods though it is laborious.

Spacing And Plant Population

A closer spacing is generally recommended for sweet potato to achieve maximum root yield. ICAR-CTCRI, Thiruvananthapuram, India has recommended a spacing of 60 cm x 20 cm for sweet potato. By adopting the above spacing, about 83000 cuttings are required to plant one ha of land. However, for rainfed uplands of Odisha, a spacing of 90 x 20 cm is recommended for getting long cylindrical shape tubers.

Manures And Fertilizers

Sweet potato removes appreciable quantities of plant nutrients, hence incorporation of FYM 5 t/ha at planting is recommended to maintain soil productivity. Application of N-P₂O₅-K₂O @ 50-25-50 kg/ha for rainfed crop and 75-50-75 kg/ha for irrigated crop is recommended for higher yield.

After Cultivation

Weeding and earthing up

Weeds are always a source of yield losses in sweet potato when grown at wider spacing. Weeding at 30 and 60 days after planting is recommended for higher yield. Earthing up should be followed immediately after weeding in sweet potato. Generally sweet potato is grown in ridge and furrow system. Manual and mechanical weeding will disturb the ridges and expose the roots. Hence, immediate earthing up of soil is essential to reshape the ridges and cover the exposed roots in sweet potato.

Turning

After proper establishment, sweet potato starts growing vigorously. Therefore, vines should be lifted at nodes 30 days after planting and turned to other side to prevent rooting and to facilitate better tuber development at the basal end.

Irrigation

Sweet potato vines are succulent and fragile, if sufficient moisture is not available in the soil immediately after planting it dries up. Hence, sufficient soil moisture at the time of planting is to be ensured for proper sprouting and establishment of vines. Sweet potato is mostly grown under rain fed conditions. Hence, planting is carried out on rainy day or immediately after rain. It is also grown in dry season under protective irrigation. Under such conditions, if sufficient moisture is not available after planting, irrigation need to be provided on alternate days initially for the first fortnight and thereafter once in 7-10 days. Sweet potato required on an average of 2 mm of water per day in the early parts of the growing season and gradually increased to 5-6 mm of water/day prior to harvest.

Pests And Diseases

Sweet potato storage root and vine are attacked by various nematodes and insect pests. *Meloidogyne* spp. (root-knot) and *Rotylenchulus reniformis* are the major known nematode pests of sweet potatoes in the tropics. They attack the fibres as well as fleshy roots and reduce yield and quality. Also allow other pathogens to penetrate through the wounds. Nematodes can be controlled by applying neem cake 500 kg/ha in the last ploughing before ridge and furrow making. Sree Bhadra variety from India is found to be resistant to root knot nematode.

Sweet potato weevil (*Cylas formicarius*) is a major pest in most sweet potato growing countries.

Seed Systems

In India, there are three types of seed system in sweet potato is followed. They are,

1. Farmers-farmers system
2. Centralized system (Govt. organizations producing and selling to farmers)
3. De-centralized system (farmers are producing under the supervision of Government agency – seed farmers- seed village)

In the above systems, 90% seed requirement is met through farmers-farmers system. De-centralized system contributes 8% of seed requirement of farmers and 2% through Centralized seed system.

Nursery Preparation

Sweet potato is usually propagated through vine cuttings, tubers/roots and tissue culture plantlets. Vine is the most popular source for planting materials production. Vine being a byproduct of the sweet potato crop and will involve no cost. Further, it is easy to establish in the nursery. Vine cuttings are better planting material than tubers because it is free from soil borne diseases. Vine cuttings are obtained either from freshly harvested plants or from nursery. However, recurrent use of vines can cause increased weevil infestation, even though there is less change of root yield reduction. Vines obtained from nursery should be healthy and vigorous for maximum root production.

Tubers/roots are easier to transport to longer distance and also can delay in establishing nursery by storing the tubers/roots during unfavourable weather conditions. It is advised to use tubers/roots for vine production once in three years to prevent genetic degeneration of the varieties.

Primary nursery

The nursery preparation starts 3 months prior to planting in the main field. For planting one ha of land, about 100 m² of primary area and about 100 kg of medium size weevil free seed roots (125-150 g each) are required. The roots are planted at spacing of 20 cm on ridges formed 60 cm apart. To ensure quick growth of vines, it is top-dressed with 1.5 kg urea/100 m² at 15 days after planting (DAP). The nursery is irrigated on every alternate day for the first 10 days and thrice in a week thereafter. At 45th day the vines are cut to a length of 20-30 cm for further multiplication in the second nursery.

Secondary nursery

To produce enough planting material to plant one ha of land, vines obtained from the primary nursery are further multiplied in the secondary nursery to an extent of 500 m². Farm yard manure or compost 500 kg is applied at the time of preparation of nursery bed and ridges are formed at a spacing of 60 cm apart. Vines obtained from the primary nursery or from freshly harvested crop

Larvae and adult feed on the roots, causing extensive damage both in field and storage in many parts of the world. The weevil can be effectively managed by following the integrated pest management (IPM) strategy. The IPM is as follows: (1) dip the vine cuttings in fenthion or fentrothion 0.05% solution for 10 min before planting, (2) re-ridge the crop two months after planting, (3) install synthetic sex pheromone traps at 1 trap/100 m² area to collect and kill the male weevils and (4) destroy the crop residues after harvest by burning.

In sweet potato, diseases are observed in field conditions but the severity is less. Fungal diseases are not normally very serious in the tropics in field conditions. Virus diseases may attack the root or the leaves. They include internal cork disease and mosaic virus. More than 12 virus diseases are identified; among them sweet potato feathery mottle virus (SPFMV) is prominent. The virus diseases can be managed through field tolerant varieties, use of virus free planting materials as well as meristem cultured plants.

Harvesting

The crop matures in 90-120 days after planting depending on variety and environmental conditions. Harvesting sweet potato within 120 days of planting is normally recommended. Delay in harvesting increases sweet potato weevil infestation. Light irrigation 2-3 days before harvesting of tubers make easier digging. Early maturing cultivars can be harvested 90-105 days after planting, whereas, medium and late maturing cultivar at 110 and 120 days after planting, respectively.

Yield

The storage root yield varies with the variety, season of planting, soil conditions and fertility. In general the storage root yield varies from 15-20 tonnes/ha for promising varieties with improved crop management practices.

Marketing

Freshly harvested tubers of sweet potato are marketable. Curing of sweet potato tubers after harvest for one day under warm conditions or 2-3 days in shaded conditions is essential for healing the wounds caused during digging and preventing fungal diseases during distance transporting. Sweet potato is highly prone to weevil damage hence delay in harvesting reduces the marketability.

Storage

Tubers are to be stored in well-ventilated rooms. If stored for longer period shrinkage results due to dehydration and several other forms of post-harvest losses.

Utilization

Sweet potato storage roots are used as human food after boiling/baking. In developing countries, it serves as staple or secondary staple food. Sweet potato roots can also be utilized for animal feed, starch production, as an ingredient in a variety of food and drink products and protein and

enzyme production. Culled roots and vines are utilized as animal feed either directly or processed.

Problems, Challenges And Future Perspectives

The agronomical advancement in sweet potato has increased tuber yield 10-30% in many of the sweet potato growing countries. In the era of climate change and soil degradation, generating eco-friendly, site specific sustainable agro-techniques through well designed research is essential to improve sweet potato productivity. Regions, where sweet potato is already staple food has great potential to improve the agro-techniques so that cheap food continues to be readily available to vast number of people. Strategic and sustainable investments in to sweet potato agronomical research will make a major contribution to the food security and livelihood improvement of the poor people.



Fig. 1. Sprouted tuber



Fig. 2. Tubers planted in a ventilated bed before taking to open field nursery



Fig. 3. Direct planting of tubers in open field nursery

Summary

Sweet potato a staple food crop in many of the developing countries also serves as animal feed and raw material for many industrial products. It requires a moderately warm climate (21-26°C) with soil pH of 5.5-6.5. Availability of quality planting material is the major constrains in sweet potato cultivation. In India, there are three types of seed system in sweet potato is followed. They are: 1. Farmers-farmers system, 2. Centralized system (Govt. organizations producing and selling to farmers) and 3. De-centralized system (farmers are producing under the supervision of Government agency – seed farmers- seed village). Sweet potato is usually propagated through vine cuttings, tubers/roots and tissue culture plantlets. Vine is the most popular source for planting materials production. Vine being a byproduct of the sweet potato crop and will involve no cost. However, recurrent use of vines can cause increased weevil infestation, even though there is less change of root yield reduction. Tubers/roots are easier to transport to longer distance and also can delay in establishing nursery by storing the tubers/roots during un-favourable weather conditions. It is advised to use tubers/roots for vine production once in three years to prevent genetic degeneration of the varieties. *Invitro* production of tissue culture plant lets can also maintained in nursery after proper hardening. These *invitro* generated planting materials are mostly free from virus. Vines from tissue culture plantlets produce uniform plant growth. Planting material production through tissue culture method is suggested for once in five years to prevent virus diseases.

7. SEED SYSTEM IN FRUIT CROPS

Dr. M. Sankaran

Head of Division, Division of Fruits, ICAR- Indian Institute of Horticultural Research, Bengaluru

Status of fruit production in national level was discussed. The planting material requirement is 22 crore of which 15 crore is for banana. Various efforts by IIHR in ensuring availability of QPM in case of fruit crops was presented and the Clean Plant Programme (CPP) of Govt. of India implemented in fruit crops was also mentioned. The banana's invitro multiplication has been suggested as classical example of success in vegetative propagated fruit crops. In bioreactor technology (scaled up and automated method of micropropagation which mostly use liquid medium with high multiplication rate and reduced production cost), about 45000 plants could be produced from single explant and in cell suspension culture it is increased to one lakh plants.

Efforts by ICAR- IIHR for strengthening seed system of fruits:

For all practical purpose, seed material of fruits are high volume and vegetatively propagated. Variety licensing is one of the approach followed for its faster spread. Non exclusive licenses awarded to interested nursery men after entering into a Memorandum of Agreement (MoA) in 500 rupees stamp paper.

IIHR initiative include release of varieties (54 varieties out of which 13 in fruits, 26 in vegetables and 10 in flower crops

In Clean Plant Programme, the diagnostic units are under ICAR institutes for respective crops and clean plant centres under ICAR, SAU and KVKs and accredited nurseries as well as licensees of ICAR

NHB is taking care of certification and accreditation of nurseries.

DBT certifies the material for freedom of disease / virus

Quality tests consists of

1. Genetic fidelity test and bar-coding
2. Virus/fungus/insect tests
3. Soil born diseases and nematodes tests

Supplied through online Krishi portal, ATIC etc.

SOP for certification is being developed for fruits

Example for Farmer varieties popularized with the help of IIHR include jack fruit Sidhu, Sankara

In guava rapid multiplication via cuttings is being developed.

Implementation of seed village programme through RFS. Buy back agreement with grower/seed producer at a price below the selling price by ICAR -IIHR so that over head charges are met. Charges for field inspection will be borne by ICAR-IIHR. Original planting material supplied by ICAR -IIHR

In case of farmer varieties, the revenue sharing is 75:25 by developer farmer and ICAR-IIHR during initial three years and then 50:50. Hence, a win-win situation for both parties

Online sale of vegetable seeds through ATIC

Way forward

- Licensing of varieties is essential for multiplication and popularisation
- Supply of genetic stock/breeder seed should be ensured
- Adoption of standard/uniform package of practices
- Field inspection at regular interval and rouging
- Buy back agreement is most important in case of participatory seed production
- Screening of seed/planting material for genetic purity, acceptance/rejection of lots

Timely payment to seed producers to be ensured

8. SEED SYSTEM IN ORNAMENTAL CROPS

P. Naveen Kumar, T. Usha Bharathi, Anuradha, R.T., Sumangala, H. P., and Rajiv Kumar

ICAR-Indian Institute of Horticultural Research, Bengaluru

E mail: P.Naveen@icar.gov.in

Floriculture, a vital part of horticulture industry, involves the cultivation, processing, seed and planting material production, and marketing of ornamental plants. During the year 2023-24, 297 thousand hectares were under floriculture in India with the estimated production of 2,284 thousand tonnes of loose flowers and 947 thousand tonnes of cut flowers. The country exported 19,677.89 metric tonnes of floriculture products globally, earning ₹717.83 crores (USD 86.63 million). Indian floriculture market reached INR 262.1 billion in 2023 and is expected to reach INR 714.6 billion by 2032, exhibiting a growth rate (CAGR) of 11.4% during 2024-2032. Over 300 export units, primarily in Karnataka, Andhra Pradesh, and Tamil Nadu, are driving growth, supported by foreign collaborations to boost global trade. Indian floriculture is characterized by the cultivation of flowers that are basically suited for garland making, worship and decoration. This industry has been shifted from traditional loose flowers to cut flowers for niche and export markets. Earlier varieties were mainly bred for loose flower and landscape purpose. Recent improved breeding techniques helped to develop many commercial flower varieties suitable for cut flower, pot culture, essential oil and pigment extraction

Flower Crop Breeding in India

History of breeding dates back to as early as 700 B.C., when Assyrians and Babylonians hand pollinated date palms. First artificial hybrid 'Fairchild Mule from Sweet William x Carnation (*Dianthus barbatus* × *Dianthus caryophyllus*) was developed by Thomas Fairchild in 1717. In 1789, Sir Joseph Bank introduced 7000 new ornamental plants species to England from China and India which include Rose and Chrysanthemum. In India, development of varieties in flower crops is not new, initially private nurserymen or amateur breeders developed several varieties in ornamental crops. Development of varieties in flower crops documented record goes back to the year 1935 in which a rose variety named 'Dr. S. D. Mukherjee' was developed by Sh. B. K. Roy Choudhary. Since, then number of varieties suitable for gardening were developed in various flower crops like rose, chrysanthemum, gladiolus, hibiscus, bougainvillea, tuberose, jasmine, aster, marigold, etc.

Variety development in flower crops

The premier institutes like IARI, New Delhi (rose, gladiolus, chrysanthemum, marigold), IIHR, Bengaluru (rose, gladiolus, tuberose, carnation, gerbera, marigold, jasmine, crossandra), NBRI, Lucknow (chrysanthemum, gladiolus, bougainvillea) and few State Agricultural Universities (SAU's) like MPKV, Pune, PAU, Ludhiana, YSPUHF, Solan, etc., were developing flower varieties in India. In addition to that, various private companies are involved in the development

of varieties in flowers crops suitable for commercial cultivation and pot plant purpose. The private firms like Indo-American Hybrid Seeds, KF Bio, KSG Sons, Florence Flora, Risenshine, Precision AgriTech are presently working towards development of and multiplication of flower crops varieties. In public sector, the improved marigold varieties, PusaNarangiGainda and PusaBasantiGainda developed by Dr S P S Raghava at ICAR-IARI way back in early nineties is the major breakthrough in the development of varieties for commercial production. Last ten years or so is so productive with respect to development of improved flower crop varieties in India. Almost in all commercial flower crops (rose – open field as well as polyhouse; gladiolus, chrysanthemum, marigold, aster, tuberose, crossandra, gerbera, *etc*), varieties have been developed.

Testing, release and notification of flower crop varieties in India

Various conventional and advanced breeding approaches are used for development of new varieties/lines. The performance of improved varieties/lines are evaluated across the country in different agro climatic zones under All India Coordinated Research Project (AICRP) centres, ICAR institutes, SAUs for a minimum period of three years/seasons, before consideration of release for cultivation. Whereas the private registered seed companies enter their improved strains/hybrids in the AICRP centres of respective crop for multilocation testing. The new variety/line is first tested for yield under the initial varietal trials (IVT) for one year and for two years under Advanced Varietal Trials (AVT). The varieties/lines which show good yield performance in AVT for two years are identified as superior strains and are considered for release. The new agro and plant protection techniques required to obtain potential yield of new variety/line are also developed by that time. Based on the three-performance evaluation, the superior varieties/lines are recommended for release by the AICRP workshops. The proposal for release of new varieties were submitted to variety release committee *viz*, state variety release committee (SVRC) and central variety release committee (CVRC). In case of SVRC, Director of Agriculture for field crops and Director of Horticulture for vegetable and horticulture crops is the Chairman. Deputy Director General (Crop Science) of ICAR is the Chairman for the CVRC. The release proposal of varieties recommended for All India release submitted to CVRC, while the varieties for a particular state is placed before the SVRC of respective state. These committees consist of scientists and representatives of seed producing organizations (NSC, SSC and SSCA) and other related government agencies.

Crops with approved seed standards are Gazette notified by Department of Agriculture Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India. In flower crops seed standards are available for some of annuals like Annual carnation, Annual chrysanthemum, Aster, Marigold, Marigold hybrids, Ornamental sunflower, Ornamental sunflower hybrids, Petunia, Petunia hybrids, Snapdragon, Snapdragon hybrids. Other than this Indian Institute of Horticultural Research (IIHR) has developed seed

standards for tuberose, chrysanthemum, gladiolus, crossandra, rose and gerbera. After release and notification of variety, seeds/planting materials are produced and distributed to farmers by government agencies/schemes like National Seed Corporation (NSC), National Food Security Mission (NFSM) and the Mission for Integrated Development of Horticulture (MIDH) private companies, and cooperatives through seed chain system.

Released and notified varieties of flower crops from ICAR-IIHR, Bengaluru suitable to enter in seed chain for seed and planting material production are as follows

S.No.	Crop	Type	Variety	Recommended zones
1	Tuberose	Hybrid	Arka Sugandhi	West Bengal and Orissa
2	Tuberose	Hybrid	Arka Prajwal	West Bengal, Assam, Punjab, Uttar Pradesh, Bihar, Rajasthan, Delhi, Maharashtra, Karnataka, Tamil Nadu
3	Tuberose	Hybrid	Arka Vaibhav	West Bengal, Assam, Rajasthan, Delhi, Maharashtra, Karnataka, Tamil Nadu
4	Gladiolus	Hybrid	Arka Manorama	Punjab, Rajasthan, New Delhi and Maharashtra
5	Gladiolus	Hybrid	Arka Amar	Himachal Pradesh. Punjab, Jharkhand. Andhra Pradesh, Maharashtra
6	Gladiolus	Hybrid	Arka Pratham	West Bengal, Punjab, Rajasthan and Maharashtra
7	Gladiolus	Hybrid	Arka Kesar	Himachal Pradesh, Rajasthan and Karnataka
8	Gladiolus	Hybrid	Arka Aayush	West Bengal, Punjab, Rajasthan and Maharashtra
9	Gladiolus	Hybrid	Arka Naveen	Punjab, Rajasthan, Bihar and Delhi
10	Crossandra	Variety	Arka Shravya	Andhra Pradesh Maharashtra, Karnataka,
11	Crossandra	Variety	Arka Shreeya	Andhra Pradesh, Maharashtra, Karnataka,
12	Crossandra	Hybrid	Arka Chenna	Maharashtra and Karnataka
13	Crossandra	Hybrid	Arka Ambara	Maharashtra, Telangana and Karnataka
14	Aster	Variety	Arka Aadya	Himachal Pradesh, West Bengal
15	Aster	Variety	Arka Kamini	West Bengal, Karnataka, and Tamil Nadu
16	Marigold	Hybrid	Arka Bangara	Odisha
17	Marigold	Hybrid	Arka Bangara -2	Assam. Bihar. Orissa. Tamil Nadu and Karnataka.
18	Marigold	Hybrid	Arka Agni	Himachal Pradesh. Assam. Orissa. Maharashtra. Tamil Nadu and Karnataka.
19	Marigold	Variety	Arka Pari	Orissa and Chhattisgarh.
20	Marigold	Variety	Arka Madhu	Chhattisgarh and Karnataka.
21	Chrysanthemum	Variety	Arka Chandrika	Odisha
22	Chrysanthemum	Variety	Arka Usha Kiran	Himachal Pradesh
23	Chrysanthemum	Variety	Arka Pink Star	Tamil Nadu, Uttarakhand, Rajasthan, Punjab, Andhra Pradesh and Odisha
24	Chrysanthemum	Variety	Arka Kirti	Himachal Pradesh and Punjab.

Quality Planting Material Production of Flower Crops

Identifying suitable flower crops and high demand varieties followed by seed production through public private partnership, could improve the availability of quality planting material to the flower growers and farmers. ICAR-Indian Institute of Horticulture Research (IIHR), Bengaluru facilitated release and notification of flower crops varieties by preparing and submitting the seed standards in respective crops and instrumental in promoting and implementing farmer participatory approach and seed village concept successfully producing flower seeds and planting material of vegetatively propagated crops. This system supplies quality seeds and planting materials nationwide. Policy interventions to promote similar approaches in public institutions could address the growing demand for flower crop seed and planting material. Establishing clear agreements with private companies, NGOs, and Krishi Vigyan Kendras (KVKs) for licensing of varieties with the outline of terms of use, royalties, and quality standards would be useful in promotion of quality planting material production in flower crops. Many private companies have started producing seeds on a large scale for export to Holland, the U.K., the USA, France, Germany and Japan. At present, in India, the area under flower seed production is about 600–800 ha. Punjab (Sangrur, Patiala, and Ludhiana); Haryana (Panipat, Sirsa); Karnataka (Bengaluru, Ranebennur); Himachal Pradesh (Kullu Valley); J & K (Sri Nagar Valley); and West Bengal (Kalimpong) are the principal flower seed production regions in India. With a turnover of more than 60 million, Punjab alone contributes to 45–50 % of these, or 450 hectares, of seed production areas. Likewise, participatory seed production (PSP) through outsourcing is a collaborative approach where farmers, organizations, or institutions work together to produce high-quality seeds. In this approach farmers who are willing to participate in seed production are identified and provided training for maintaining genetic purity, isolation distances and proper harvesting methods. ICAR and other institutions has been successful in producing certified seeds of various crops and also empowers farmers economically.

In, Revolving Fund Scheme (RFS) Nodal officer in consultation with concerned breeder will conduct field inspection and provide technical support for the production of quality planting material based on demand and supply.

Strategies /Future thrust

- Development of indigenous varieties for domestic as well as for export purpose
- Strengthening conventional seed production system by involving SAU's/SHU's, KVKs, NGOs, FPOs, FPCs, etc would help in the quality seed and planting material production
- Creation of awareness on the successful models like Seed Village Concept or Participatory Seed Production involving progressive farmers

- Encouraging and ensuring the greater involvement of NSC, State Seed Corporations & other Govt agencies for the flower seed production
- Refining conventional propagation protocols for rapid and large-scale multiplication enhances reach of the flower crop varieties
- Use of micro-propagation/bioreactors for rapid and large-scale propagation of bulbous and other planting material
- Awareness about IPRs, PBRs & PVP facilitates use of elite varieties from abroad
- Documentation and database creation on demand and supply of quality planting material in flower crops

9. TOWARDS SUSTAINABLE SEED SYSTEMS IN SPICES: TECHNICAL AND POLICY INSIGHTS

Dr. Lijo Thomas

Senior Scientist, Agricultural Economics

ICAR- Indian Institute of Spices Research, Marikunnu PO, Kozhikode

Introduction

In a nation where spices are not just condiments but an integral part of culture, economy, and livelihoods, the health of our spice industry hinges critically on one often-overlooked element: the seed system. India's diverse spice basket is cultivated by millions of farmers, yet the foundational aspect of quality planting material often remains informal and unorganized. While the challenges faced are multifaceted, the improvement of seed systems hold significant latent potential in improving the spice economy. Development of a sustainable seed systems in spices needs changes in both technical perspectives and policy design to cultivate a more robust future for this vital agricultural sector. Spices, encompass a botanically diverse group of crops including rhizomatous crops (ginger, turmeric, cardamom), perennial vines (black pepper), tree crops (nutmeg, clove, cinnamon, garcinia), and even orchids like vanilla. Despite their diversity and economic significance, seed systems in spices remain underdeveloped, lacking formal frameworks and streamlined institutional support. This article presents technical and policy insights for evolving sustainable seed systems in spices, drawing from field experiences and institutional learnings, particularly from ICAR-IISR.

Demand management

Demand management of planting material is one of the most challenging aspects of the seed system. For this, accurate estimates of planting material demand is a basic requirement. Developing realistic seed demand scenarios for spices is a multifaceted challenge that necessitates a comprehensive understanding of various interconnected factors. A crucial starting point involves assessing the existing area under modern varieties (MV), as this provides a baseline for current adoption and potential for future growth or replacement. Concurrently, the significant prevalence of farmer-to-farmer seed exchange must be accounted for, as this informal channel fulfills a substantial portion of planting material requirements but often bypasses formal seed systems. Furthermore, accurately estimating replacement demand is vital, which includes both a targeted replacement rate for old varieties (typically 5-10%) to ensure varietal rejuvenation and disease management, and the ongoing replacement demand arising from the existing area already under modern varieties due to natural decline or physiological aging of the planting material. Finally, projections for demand arising from area expansion, with

an expectation that 40-50% of this new demand will be met through organized seed systems, are critical for forecasting future needs and guiding investment in seed production infrastructure.

Seed demand in selected spice crops

The demand for planting materials is estimated based on factors like spread of improved varieties, pace of varietal replacement, estimate of planting material produced for own use by farmers etc.

Black pepper

The total area under black pepper is estimated to be 2,78,050 hectares. Out of this area about 60 per cent is planted with improved modern varieties like panniyoor varieties, Thevam, Sreekara, Subhakara, Panchami etc. The crop can be easily vegetatively propagated and the process of production of new planting material is easy and of common knowledge among the farming community. Farmer to farmer exchange of planting material is also prevalent in several black pepper growing regions. Targeting a replacement rate of 5 per cent per year and a replacement demand of 5 percent, the planting material demand is estimated as follows

Replacement demand from area planted under old varieties (Replanting and replacement) = 5561 ha, Of which 60 percent to be met by planting material system other by farmer sources = 3337 ha

Replacement demand (5 %of existing area under Modern varieties) = 8341 hectares.

Demand for new planting = Assuming 3 per cent growth rate of area = 4171 ha

Total demand = 17.44 million planting units(@ 1100 planting units per ha)

Cardamom

Presently, the total area under cardamom is about 70,000 ha. The varietal scenario is dominated by a single farmer variety Njallani, which is estimated to have spread to about 80 per cent of the area under the crop. Vegetative propagation through suckers is the recommended practice in cardamom, which can be easily adopted by farmers. In this crop also, farmer to farmer sourcing and exchange of planting material is prevalent. Considering the need for varietal diversity and the farmer demand for modern varieties developed by research institutions, it is estimated that a 3 per cent replacement of Njallani could be targeted for slowly effecting varietal diversity in the crop. Considering the longevity of the crop and replacement demand arising from loss due to biotic and abiotic stress elements, a replacement demand of 12 per cent of the other varieties is expected. The planting material supply system need to be prepared to meet about 40 per cent of this demand also. Total Planting material demand = 26.03 lakhs per year

Ginger

The bulky nature of seed material, relatively low multiplication rate (compared to cereals and pulses for example) and high seed rate (2.5 tonnes per ha) has traditionally limited cross regional movement of seed material in large scale. However, the easy method of vegetative propagation has led to the emergence of farmer practice of saving seed material for own use in the crop. At present, ginger is cultivated in 205899 ha. The spread of modern varieties has remained weak (about 20 per cent) in the crop due to several factors. The difficulty in transporting the bulky seed material is one of the major constraints in enhancing the pace of ginger varietal spread. Farmers try to source the planting material from sources close to them, leading to the emergence of farmer to farmer transactions for seed procurement. The planting material system should focus on the spread of modern varieties by developing a seed chain with exclusive focus on such varieties. The traditional varieties is envisaged to continue its presence through demand based farmer to farmer sourcing leaving seed chain to focus exclusively on MV.

Area under MV = 20 % of 205899 = 41180 ha

Targeted area expansion of MV = 8 per cent of 41180 = 3294 ha

30 per cent of this demand to be met by FTF system = 908 therefore, seed demand to be met by Seed chain = 2386 ha for 2024-25. Assuming 10 per growth in this demand the demand for 2025-26 season will be = 2624 ha. To meet this demand we need to produce Foundation seed for 262 ha (Assuming multiplication ratio of 10 times). This would require 655 tonnes of seed material meeting foundation seed quantity parameters during 2024-25.

Institutional challenges in spice seed systems

Institutional challenges represent a significant hurdle in formalizing and strengthening spice seed systems, beginning with a fundamental lack of clarity regarding the precise role of research institutes. A key debate revolves around whether the research institutes should actively engage in large-scale production of planting material to directly enhance availability, or if their focus should be an indirect, facilitative one, concentrating instead on core mandates such as developing superior varieties, providing robust varietal testing services, and streamlining licensing procedures for private or cooperative producers. Compounding this, institutes and policymakers must navigate how best to handle the coexistence of multiple, often disparate, channels for seed supply; these include formal commercial licensing agreements, structured seed chains established under the Seed Act, and more decentralized approaches like Farmer Participatory Seed Production (FPSP) and community-driven seed villages. Beyond these definitional and structural issues, broader challenges within the seed system persist, including the critical need for effective mechanisms to incentivize private sector firms, farmer collectives

and cooperatives to undertake organized seed production, a step vital for decentralization and reach, and addressing weak enforcement mechanisms that undermine quality control and trust within the entire seed value chain.

Farmer participatory seed production: The IISR Experience

Farmer participatory seed production was initiated by ICAR-IISR on a limited scale during the 2020–21 crop season as an innovative model to decentralize quality seed production and strengthen farmer involvement in the seed system. Under this initiative, selected farmers entered into formal agreements through a Memorandum of Understanding (MoU) with the institute, outlining mutual responsibilities and expectations. A key feature of the model was the buy-back arrangement, which provided the participating farmers with market assurance and pricing incentives. The institute introduced a pricing mechanism that guaranteed the higher of either the Agmarknet-reported market prices from designated locations during a specified period or a pre-fixed base price. For instance, in the case of ginger, the benchmark markets were Kozhikode and Coorg, with a base price fixed at ₹50 per kg.

The initial seed material was supplied free of cost by the institute, with the equivalent weight being adjusted at the time of procurement. Throughout the crop cycle, ICAR-IISR provided regular technical support, including field visits and advisory services, ensuring monitored production and adherence to quality standards. The risk of production was jointly borne by the farmer and the institute, with certain protocols such as the timing of harvest being clearly specified in advance. This participatory model not only ensured the availability of quality planting material but also empowered farmers through a transparent and supportive institutional framework.

Challenges in farmer participatory seed production

Despite its promise, farmer participatory seed production faces several operational and institutional challenges that can hinder its scalability and effectiveness. One of the foremost limitations is the lack of dedicated and sustained operational funding. Since such initiatives often operate outside the framework of regular research projects, securing consistent financial support for critical activities like seed multiplication, quality monitoring, field visits, and logistics becomes a major constraint. This financial uncertainty affects the continuity of the program and limits its ability to expand beyond pilot scales, despite evident farmer interest and positive initial outcomes.

Another layer of complexity arises from conflicting interests between farmers and the implementing institution. These include disagreements related to weight loss during post-harvest handling and storage, especially for perishable planting materials like ginger and

turmeric. Farmers may be reluctant to accept deductions for natural weight loss, while the institute must maintain strict quality and accountability standards. Additionally, adherence to the prescribed time of harvest can be a point of contention. While the institute emphasizes timely harvest for quality assurance and procurement planning, farmers may prefer to delay or advance harvest based on weather conditions, market signals, or labour availability. These misalignments, though manageable, require strong communication, mutual trust, and well-defined contractual safeguards to ensure smooth collaboration and minimize friction.

Commercial challenges and policy gaps

The spice seed sector is confronted with a range of commercial challenges and policy gaps that hinder its formalization and long-term sustainability. Unlike field crops with established seed markets, spice crops are propagated through bulky and perishable planting materials such as rhizomes, cuttings, or grafted plants, making the seed segment a high-volume but low-value domain. This characteristic significantly reduces its commercial appeal, particularly for private players who often shy away due to poor return on investment and the absence of scalable models. The initial cost of establishing seed production units—considering infrastructure, disease-free mother stock, and skilled labour—is also considerably high, especially when quality assurance and certification mechanisms are factored in. Moreover, many spice seeds require specialized transportation and handling protocols to preserve viability and prevent pest or disease transmission, further inflating costs and logistical complexity.

Adding to the problem is the limited availability of real-time, region-specific market intelligence on seed demand and supply trends, which hampers effective planning and business development. The absence of robust information systems prevents both public institutions and emerging seed entrepreneurs from responding to shifts in varietal preferences or geographic demand patterns. Compounding these issues is a broader policy vacuum where regulatory clarity is lacking on seed standards for spices, certification frameworks, and the role of informal systems such as farmer-to-farmer exchanges. The lack of targeted incentives or support schemes for seed entrepreneurship in spices further weakens the development of a resilient seed ecosystem. Addressing these gaps will require coordinated policy reforms, investments in infrastructure, and the creation of enabling frameworks that recognize the unique biological and market dynamics of spice crops.

The way forward: need for bold changes

Transforming spice seed systems into resilient, responsive, and farmer-centric frameworks demands bold and forward-looking interventions at both technical and policy levels. A key priority is the establishment of robust traceability systems that ensure the genetic purity, health

status, and source authenticity of planting material across the seed value chain. Such systems, supported by digital tools and institutional protocols, would enhance market confidence, reduce the risk of varietal admixture, and provide a transparent platform for monitoring seed movement. Equally important is the promotion of seed entrepreneurship, particularly among rural youth, farmer collectives, and self-help groups. Dedicated programmes that offer training, infrastructure support, credit access, and market linkage are essential to nurture a new generation of decentralized seed producers who can respond dynamically to local varietal preferences and agro-climatic conditions.

In addition to these efforts, the current reliance on static, centrally managed seed banks needs to be reimagined. Regional dynamic seed banks—closer to production zones and capable of adapting to seasonal and varietal fluctuations—can play a vital role in ensuring timely access to quality planting material. Such regional systems can also serve as hubs for on-farm conservation and participatory varietal selection. Furthermore, decentralizing seed certification by empowering local institutions and trained community-based validators will make quality assurance more practical and accessible, particularly for vegetatively propagated spice crops that do not conform easily to conventional seed certification norms. These changes require not only regulatory innovation but also a cultural shift in how seed systems are conceptualized—moving from a top-down, supply-driven approach to a more integrated, demand-responsive and ecosystem-based model. If implemented with vision and coordination, these reforms can unlock the full potential of spice seed systems to support productivity, profitability, and sustainability in the sector.

10. DECENTRALISED SEED MULTIPLIER AND SEED VILLAGE CONCEPTS IN TUBER CROPS

Dr. K. Sunilkumar

Principal Scientist, ICAR- Central Tuber Crops Research Institute, Thiruvananthapuram

Quality seed is a key input for agriculture, with a direct impact on agricultural production and productivity. Access to seeds is a vital element of food security and sustainable development (FAO,2003). The basic parameters of seed security framework includes availability, access and utilization (Sperling and Cooper, 2003; CRS-ICRISAT, 2002). With respect to seed/planting materials tropical tuber crops have certain inherent limitations and a clear understanding of such issues is essential in addressing them.

Features of tuber seed material

- Tuber crops are mostly propagated through vegetative means (via. tuber, root, stem, vine etc.). Hence vulnerable to build up of viruses or other pathogens and seed degeneration in repeated use multiplication
- Bulkiness, low multiplication rate and perishability this impact storage, transportation etc.
- While in case of grain crops (propagated through true seeds), the rate of multiplication is high (1:100 or more) whereas the tuber crops have low rate of multiplication (1: 5 to 10).
- Hence, the land area required for seed production is very high; viz.1 ha of the crop can generally produce planting materials for only 5-10 ha.
- Long crop cycle(about 9 months except for sweet potato) and dormancy periods in case of elephant foot yams and yams (2-3 months).
- Since, seed material and edible part are same in most of the cases, there is competition between Ware tuber and Seed tubers. As a result, often quality and quantity of next crop affected.
- All these attribute to shortage of quality seed/planting material which inturn has become main bottleneck in expanding production of tuber crops.
- Lack of private companies in seed production
- Total dependence on public institutions and their lack of capacity to meet the entire demand.

Comparison of key traits of tuber seed Vs grain seed

Trait	Maize	Cassava	Sweet potato	Yams	Elephant foot yam
Economic part	Seed	Roots	Roots	Tubers	Tubers
Common propagation method	Seed	Stem cutting	Roots, vine cutting	Tubers	Tubers
Rate of multiplication	70-100	10	10	8	4
Seed rate (ha)	20 Kg	2000 stems	83333 vine cuttings or 100 kg tuber	3000-3700kg	7.5t (9-12 t)*KAU recommendation
See cost (Rs)	1100-1800	4200-8400	41666	150000	270000
Storability of harvested seed	Upto 1 year	1 month	2-3 weeks for tubers	3-4 months	3 months

Improved varieties released from ICAR-CTCRI

- The ICAR-CTCRI has so far developed 77 varieties which include cassava, sweet potato, yams, elephant foot yam, taro and Chinese potato varieties.
- Improved cassava varieties include HYV, virus resistant (CMD), high starch varieties etc.
- Orange fleshed sweet potato varieties rich in β carotene and could be popularized for its effectiveness against malnutrition.
- Anthocyanin rich sweet potato and greater yam varieties are effective antioxidant as well as natural colorant for food processing industry.
- The supply of quality planting materials to farmers is of paramount importance for adoption/popularisation of such varieties.

Problems to be addressed

- Acute shortage of quality seed/planting material of improved varieties.
- The public sector does not have capacity or the reach.
- Large scale private companies are not interested or not available in the planting material sector of tuber crops.
- Seed degeneration and hence need for seed replacement at regular intervals say 4-5 years.
- Poor percolation of elite varieties mainly attributable to poor or under developed seed system.

- Complex nature of farmer demand for seed and the demand is often unpredictable.

Way forward

Conscious interventions are required to make tuber crop seed system more effective and working. A intervention in the form of 'tuber crops seed chain' is envisaged by integration of formal (public sector) and informal (farmer, FPOs, NGO etc) seed systems by which the lack of institutional capacity, lack of implementation mechanism and the lack of seed standards in the ground could be addressed.

- The seed availability and access could be improved through development of Decentralised Seed Multipliers (DSM) in promising tubers crops/varieties.
- Decentralised Seed Multipliers will be local seed producers identified for multiplication of quality planting material. It can be farmers/farmer groups/incubatees/FPOs/SHGs/Cooperatives etc under designated Krishibhavan jurisdiction.
- A village/panchayat with minimum 10 DSMs or 10 acres may be designated as seed village. They can improve the availability and access of quality planting material in each village.
- DSMs can cater to the local demand more effectively because of lower transportation costs and in turn demerits of bulky and perishable nature can be partly offset.
- Regular renewal with clean seed and a high variety replacement achievable through this can negate the issue of seed regeneration.
- Also state farm/district farm under DoA/DoH may multiply improved varieties to partly meet the demand
- Nucleus planting material/source material of elite varieties to be made available to selected DSMs by the breeder/breeding institute
- Training on (a).Quality standards and (b) Rapid multiplication techniques of tuber crops
- Technical guidance and supervision on seed quality may be provided by ICAR-CTCRI/SAU/VFPCK/similar agencies for respective varieties in association with agriculture/horticulture department.
- DSMs will be authenticated to supply Quality Declared Seed material (QDS) to various stake holders (Eg. Department of Agriculture, KVKs as well as fellow farmers).

Directory of DSMs and availability of QDS may be prepared and made available to all stake holders and need to be updated every year.

Institutionalising 'Annual tuber seed meet' to assess planting material requirement in advance of at least one season so that necessary arrangement could be made for multiplication as well as procurement by respective stake holders.

Number of DSMs and seed villages established for quality declared seed (QDS) production of tuber crops during crop season from 2021-22 to 2023-24

Year	Cassava	Chinese potato	Sweet potato	Elephant foot Yam	Greater Yams	Total number Seed villages	Area (Acres)	Total DSMs	Area (Acres)
2021-22	8	5	2	1		16	72.00	20	35.95
2022-23	14	6	4	1		25	80.00	66	52.95
2023-24	12	10	6	1	6	35	180.00	42	57.30
					Total	117	332.00	128	146.20

References

- FAO,2003.Understanding access to seeds and plant genetic resources-LSP. Shaila Seshia and Ian Scoones Eds. Working Paper 6
- Sperling, Louise; Cooper, David. 2003. Understanding seed systems and strengthening seed security. Rome, Italy: Food and Agriculture Organization.
- CRS-ICRISAT 2002. Seed Vouchers and Fairs-A Manual for Seed-Based Agricultural Recovery in Africa. Paula Bramel, Richard Jones,Catherine Longley, Jeremiah Maroko, Alisha Myers, Tom Remington Eds. Catholic Relief Services International Crops Research Institute for the Semi-Arid Tropics and Overseas Development Institute, 76p



Decentralised Seed Multipliers (DSM) of 1) Sweet Potato 2) Chinese Potato 3) Cassava

11. SEED CERTIFICATION STANDARDS IN TROPICAL TUBER CROPS

Dr. R. Muthuraj

Principal Scientist, ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram

As per the national policy of seed multiplication, phases of seed have been grouped into three categories i.e. i) Breeder or basic seed; ii) Foundation Seed- I and Foundation Seed –II and iii) Certified Seed.

The breeder seed is considered to be pure, disease free and no tolerance limit is fixed while for foundation (FS I and FS II) and certified seed the tolerance limits for viruses off-type, tuber-borne diseases and grades have been fixed by Government of India. Breeder seed is only being monitored by the certification agency but it is not certified by them.

In India, there are nineteen state seed certification agencies in different states certifying the seed of different crops. The states in which seed certification is in operation are Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Jammu& Kashmir, Karnataka,

Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Sikkim, Tamil Nadu, Uttar Pradesh, West Bengal and Delhi.

General Seed Certification Standards

The General Seed Certification Standards are applicable to all crops which are eligible for certification, and having field and seed standards for the individual crops, shall constitute the Minimum Seed Certification Standards. The word 'Seed' or 'Seeds' as used in these standards shall include all propagating materials.

I. Purpose of Seed Certification: The purpose of seed certification is to maintain and make available to the public, through certification, high quality seeds and propagating materials of notified kind and varieties so grown and distributed as to ensure genetic identity and genetic purity. Seed certification is also designed to achieve prescribed standards.

II. Certification Agency: Certification shall be conducted by the Certification Agency notified under Section 8 of the Seeds Act, 1966.

III. Certified Seed Producer: Certified seed producer means a person/organization who grows or distributes certified seed in accordance with the procedures and standards of the certification.

IV. Eligibility Requirements for Certification of Crop Varieties: Seed of only those varieties which are notified under Section 5 of the Seeds Act, 1966 shall be eligible for certification.

V. Classes and Sources of Seed

A. Breeder Seed Breeder seed is seed or vegetative propagating material directly controlled by the originating or sponsoring plant breeder of the breeding programme or institution and/or seed whose production is personally supervised by a qualified plant breeder and which provides the source for the initial and recurring increase of Foundation seed.

Breeder seed shall be genetically so pure as to guarantee that in the subsequent generation i.e. certified Foundation seed class shall conform to the prescribed standards of genetic purity. The other quality factors of Breeder seed such as physical purity, inert matter, germination etc. shall be indicated on the label on actual basis. The Breeder seed shall be packed and supplied by the breeders in the form and manner indicated in

B. *Certified Seed* Certified seed shall be the seed certified by Certification Agency notified under Section 8 of the Seeds Act, 1966 or seed certified by any Certification Agency established in any foreign country provided the Certification Agency has been reorganized by the Central Government through notification in the Official Gazette. Certified seed shall consist of two classes, namely, Foundation and Certified seed and each class shall conform to the following description:

1. Certified Foundation seed shall be the progeny of Breeder seed, or be produced from Foundation seed which can be clearly traced to Breeder seed. Thus, Foundation seed can even be produced from Foundation seed. During the production of certified Foundation seed, the following guidelines shall be observed:

- (a) Certified Foundation seed produced directly from Breeder seed shall be designated as Foundation seed stage-I;
- (b) Certified Foundation seed produced from Foundation seed stage-I shall be designated as Foundation seed stage-II;
- (c) Certified Foundation seed stage-II will not be used for further increase of Foundation seed and shall be used only for production of Certified seed class;
- (d) Minimum Seed Certification Standards shall be the same for both Foundation seed stage-I and II unless otherwise prescribed;
- (e) Certification tag shall be of white colour for both Foundation seed stage-I and II and shall contain the information as to its stage;
- (f) Production of Foundation seed stage-II shall ordinarily be adopted in respect of such crop varieties provided, when it is expressly felt by the Certification Agency that Breeder seed is in short supply;
- (g) Production of Foundation seed stage-II may be adopted for the following group of crops:
 - vegetatively propagated crops;
 - apomictically reproduced crops;
 - self-pollinated crops;
 - often cross-pollinated and cross-pollinated crops, these being gene – pools should not lose their genetic identity and purity if measures to safeguard the same are adequately taken;
 - composite and synthetics;
 - parental line in case of hybrids.

2. Production of Foundation seed stage-I and II shall be supervised and approved by the

Certification Agency and be so handled as to maintain specific genetic identity and genetic purity and shall be required to conform to certification standards specified for the crop/variety being certified. 3. (a) Certified seed shall be the progeny of Foundation seed and its production shall be so handled as to maintain specific genetic identity and purity according to standards prescribed for the crop being certified; (b) Certified seed may be the progeny of Certified seed provided this reproduction does not exceed three generations beyond Foundation seed stage-I and - it is determined by the Certification Agency that genetic identity and genetic purity will not be significantly altered; - and when the Certification Agency is satisfied that there is genuine shortage of Foundation seed despite all the reasonable efforts made by the seed producer. (c) Certification tag shall be of blue colour (shade ISI No. 104 AZURE BLUE) for Certified seed class. (d) Certified seed produced from Certified seed shall not be eligible for further seed increase under certification. Certification tags for such production which is not eligible for further seed increase under certification shall be super scribed with, “not eligible for further seed increase under certification”.

VI. Phases of Seed Certification Certification shall be completed in six broad phases listed as under:

- (a) receipt and scrutiny of application
- (b) verification of seed source, class and other requirements of the seed used for raising the seed crop;
- (c) field inspections to verify conformity to the prescribed field standards;
- (d) supervision at post-harvest stages including processing and packing;
- (e) seed sampling and analysis, including genetic purity test and/or seed health test, if any, in order to verify conformity to the prescribed standards; and
- (f) grant of certificate and certification tags, tagging and sealing.

VII. Establishing Source of Seed

The individual intending to produce seed under certification shall submit to the Certification Agency, one or more relevant evidence such as certification tags, seals, labels, seed containers, purchase records, sale records etc., as may be demanded by the Certification Agency during submission of the application, its scrutiny and/or during first inspection of the seed crop, in order to confirm if the seed used for raising the crop has been obtained from the source approved by it and conforms to the provisions contained in para V. This requirement also applies to both parents in seed production involving two parental lines.

VIII. Field Area for Certification There is no minimum or maximum limit for the area offered by a person for certification, provided the certified seed production meets all the prescribed requirements.

IX. Unit of Certification For the purpose of field inspection, the entire area planted under seed production by an individual shall constitute one unit provided:

- (a) It is all under one variety;

- (b) It does not exceed ten hectares;
- (c) It is not divided into fields separated by more than fifty meters between them;
- (d) It is planted with or is meant to produce seed belonging to the same class and stage in the generation chain;
- (e) The crop over the entire area is more or less of the same stage of growth so that observations made are representative of the entire crop;
- (f) The total area planted, by and large, corresponds to the quantity of seed reported to have been used; and the Certification Agency's permission had been obtained to sow a larger area by economizing on seed rate; if that the case;
- (g) Raised strictly as a single crop and never as mixed;
- (h) Not so heavily and uniformly lodged that more than one third of the plant population is trailing on the ground leaving no scope for it to stand up again thus making it impossible for the Certification Agency to inspect the seed crop at the appropriate growth stage in the prescribed manner;
- (i) As far as possible, so maintained as to show adequate evidence of good crop husbandry thereby improving the reputation for certified seeds; and
- (j) Not grown as inter, companion or ratoon crop.

X. Use of Chemical Hybridizing Agents ('CHAs')

- (a) In case of hybrid seed production, the seed producer can use proper Chemical Hybridising Agents ('CHAs') on seed parent (female line) in order to induce male sterility. Consequently the Minimum Seed Certification Standards specified for production of 'A' and 'B' lines shall not be applicable for the relevant hybrid.
- (b) The hybrid seed produced through the application of 'CHAs' shall be compulsorily subjected to grow-out test as a pre-requisite for grant of certificate.

XI. Field inspection

- (a) The field inspection work which requires technically-trained personnel, shall be performed by the persons who have been so authorized by the Certification Agency;
- (b) Field inspection meant to verify those factors which can cause irreversible damage to the genetic purity or seed health shall be conducted without prior notice to the seed producer;
- © Soon after the completion of the field inspection, a copy of the report shall be handed over to the seed producer or his representative.

XII. Re-inspection: Seed fields not conforming to prescribed standards for certification at any inspection, the Certification Agency shall, upon the request of seed producer and after he removes the sources of contamination in the seed field and within the prescribed isolation distances and/or the contaminated plants in the seed field (if so directed by the Certification Agency perform one or more re-inspections provided such removal can ensure conformity of the seed crop to the

prescribed standards and provided further that no irreversible damage has been caused to the quality of seed by the contaminant(s). The Certification Agency may at its discretion, also perform one or more re-inspections over and above the minimum number of inspections prescribed, if considered necessary.

XIII. Harvesting, Threshing and Transportation: Seed crop meeting field standards for certification shall be harvested, threshed and transported to the seed processing plant in accordance with the guidelines issued by the Certification Agency. During these operations, seed producer will take all precautions to safeguard the seed from admixture and other causes of seed deterioration.

XIV. Bulking: Bulking of unprocessed seed stocks to obtain larger homogeneous seed stocks may be permitted by the Certification Agency provided the stocks to be bulked meet the following requirements. belong to the same certified seed producer; belong to the same crop, variety, class of seed and stage in the generation chain; were produced in the same season and under similar agro-climatic conditions; were subjected to certification by the same Certification Agency; have more or less similar physical appearance and levels of moisture; are adequately homogenous in composition.

XV. Seed Processing and Packing Schedule: The Certification Agency shall prepare and communicate seed processing and packing schedule to all certified seed producers soon after the certification of seed crops at field stage. The seed producers shall adhere to the schedule specified by the Certification Agency. However, re-scheduling may be accepted by the Certification Agency on the request of seed producer on genuine grounds.

XVI. Seed Lot: A seed lot is a physically identifiable quantity of seed which is homogeneous.

XVII. Lot Size: A seed lot would represent any quantity of agricultural seeds upto a maximum of 20,000 kilogrammes for seeds of the size of rice or larger (except maize seed, seed potato, sweet potato, yams, taro and chow-chow for which the maximum size of the lot may be 40,000 kilogrammes) and 10,000 kilogrammes for seeds smaller than rice subject to a tolerance limit of 5.0%.

XVIII. Construction of Seed Lot Number: Each seed lot shall be assigned a specific number in order to facilitate maintaining its identity, tracing back to its origin, handling in stores, transit etc., accounting and inventory maintenance and referring/communicating about a certain quantity of seed.

XIX. Seed Processing: Seed processing means cleaning, drying, treating, grading and other operations which will improve the quality of seeds. Seed from fields which conformed to the standards of certification at field stage shall, as soon as possible after the harvest will be brought at processing plant for processing. The typical contaminants such as weed seeds, small seeds, damaged seeds, broken and shriveled seeds, straw, chaff, leaves, twigs, stones, soil particles etc. are removed. However, the Certification Agency is authorized to deviate under exigencies to use the screen of small aperture size than specified. In such cases, the Certification Agency shall record the reasons for reduction in the aperture of the screen. Processed seed shall not have seed of

the size lower than the bottom screen used beyond 5.0% (by weight).

XX. Seed Treatment: When a variety, seed of which is under certification is susceptible to a seed borne disease organism or when seed under certification is carrying a seed borne pathogen and a seed treatment is available which may control the disease or pathogen when properly applied, the Certification Agency may require such seed to undergo such treatment before Certification. In case seed is required to be treated before sowing by the user, the chemical calculated at the recommended dose shall be kept in a plastic packet and placed inside the seed container with complete direction and precautions required for treating of the seed. The information about the treatment shall also be displayed on seed containers. If the seeds have been treated, the following instructions shall also be complied with: (a) a statement indicating that the seed has been treated; (b) the commonly accepted chemical or abbreviated chemical name of the applied substance; and (c) if the substance of the chemical used for treatment and present with the seed is harmful to human beings or other vertebrate animals, a caution statement such as “Do not Use for Food; Feed or Oil purposes”. The caution for mercurials and similarly toxic substances shall be word “POISON” which shall be in type size, prominently displayed on the label in red.

XXI. Samples and Sampling of Seeds: Soon after completion of the seed processing or after seed treatment as the case may be, the Certification Agency shall draw a representative composite sample as per procedure specified in Seed Testing Manual. The quantity of seed samples so drawn shall be sufficient to provide three samples of the size of submitted sample. The composite sample will be divided into three equal parts, and one shall be sent for analysis to a notified Seed Testing Laboratory, the second part to the seed producer and retain the third part as a guard sample.

XXII. Seed Analysis Report: The Seed Testing Laboratory shall analysis the seed samples in accordance with the prescribed procedure and deliver the Seed Analysis Report to the Certification Agency as soon as may be, but not later than 30 days from the date of receipt of the samples unless the seed is subjected to such tests which require more than 30 days for completion of the test.

XXIII. Seed Standards of Genetic Purity: (a) All certified seed lots shall conform to the following Minimum Standards for genetic purity unless otherwise prescribed:

Class	Standards for Minimum Genetic Purity (%)
Foundation	99.00
Certified: (i) Varieties, composites, synthetics & multilines	98.00
(ii) Hybrids	95.00
(iii) Hybrids of cotton, TPS, muskmelon, brinjal & tomato	90.00
(vi) Hybrid castor	85.00

(b) *Grow-out Test* The Certification Agency shall conduct grow-out test to determine genetic purity of a seed lot whenever it is a pre-requisite for grant of the certificate and also on the seed lots where a doubt has arisen about the genetic purity. The grow-out test can be complemented by certain related laboratory tests.

XXIV. Recleaning, Resampling and Retesting: When a seed lot does not meet the prescribed seed standards, the Certification Agency on the request of seed producer may permit recleaning, resampling and retesting. The recleaning, resampling and retesting shall be permitted only once.

XXV. Seed Standards for Insect Damage: A seed lot under certification shall not have apparent or visible evidence of damage by insects for both Foundation and Certified seed classes in excess of 1.0% for the seeds of maize and legumes and 0.50% for the seeds other than maize and legumes unless otherwise prescribed.

XXVI. Seed Moisture Content: Seed standards in respect of seed moisture shall be met at the time of packing of seed.

XXVII. Downgrading of Seed Class: If a seed field or a seed lot is not found meeting prescribed standards for the class for which it has been registered but conforms to the prescribed standards to the immediate lower class, the Certification Agency may accept such seed fields/seed lots for certification to the immediate lower class provided request has been made to this effect by seed producer. However, downgrading of the seed class shall not be applicable in case of hybrids and their parents.

XXVIII. Specification of the Certification Tag: Size, quality, colour, lay out and contents of the certification tag shall be as specified.

XXIX. Packing, Tagging, Sealing and Issuance of the Certificate: (a) On receipt of Seed Analysis Report and the results of the grow-out test wherever prescribed, and if seed lot has met prescribed standards, the Certification Agency shall ensure packing, tagging and sealing and issuance of certificate expeditiously. An authorized official of the Certification Agency shall endorse the signature on the reverse of each certification tag and shall affix rubber stamp indicating the official's name and designation. Containers to be used for packing of the certified seeds shall be durable and free from defects. (b) Advance tagging may be permitted at the discretion of the Certification Agency with proper safeguards.

XXX. Refusal for Certification: The Certification Agency shall have the authority to refuse certification of any seed production field or any seed lot that does not conform to the Minimum Standards prescribed for that particular crop, either for field or for seed or for both. Such refusal will be subject to any appeal made to the Appellate Authority constituted under Section 11(1) of the Seeds Act, 1966.

XXXI. Validity Period of the Certificate: The validity period shall be nine months from the date of test at the time of initial certification. The validity period could be further extended for six months provided on retesting seed conforms to the prescribed standards in respect of physical purity, germination and insect damage for all seeds except vegetatively propagating material for which lot shall be re-examined for seed standards specified for respective crop. A seed lot will be eligible for extension of the validity period as long as it conforms to the prescribed standards.

XXXII. Revocation of Certificate: If the Certification Agency is satisfied, either on reference made to it in this behalf or otherwise that: (a) the certificate granted by it under Section 9(3) of the Act has been obtained by misrepresentation as to an essential fact; or (b) the holder of the certificate has, without reasonable cause, failed to comply with the conditions subject to which the certificate has been granted or has contravened any of the provisions of the Act or the Rules made thereunder, then, without prejudice to any other penalty to which the holder of the certificate may be liable under the Act, the Certification Agency may, after giving the holder of the certificate an opportunity of showing cause revoke the certificate, under the provisions of Section 10 of the Act.

XXXIII. Retention of Certification Records: The Certification Agency shall preserve in order all the documents including the guard samples pertaining to certification of each seed lot for two years from the date of grant/ extension of the certificate and four years in respect of rejected seed crops or lots from the date of communication of rejection unless and otherwise required for longer period.

Certification standards of major tuber crops are discussed below:

1. Seed certification standards for cassava (*Manihot esculenta* Crantz).

I. Application and Amplification of General Seed Certification Standards

A. The General Seed Certification Standards are basic and, together with the following specific standards constitute the standards for certification of tapioca planting material.

B. The General Standards are amplified as follows to apply specifically to tapioca:

All certified classes shall be produced from planting stakes (stem cutting) cut from the seed field whose source and identity may be assured and approved by the Certification Agency.

II. Land Requirements

(a) Land to be used for seed production of tapioca shall be free from volunteer plants. Swampy and shaded conditions might be avoided.

(b) Avoid tapioca residue and drainage from other tapioca fields.

III. Field Inspection

A minimum of four inspections shall be made,

The first field inspection about 60 days after planting

The second field inspection about 120 days after planting

The third field inspection about 180 days after planting or at appropriate growth stage depending on the crop duration of the variety concerned and

The fourth field inspection prior to cutting of planting stakes to verify isolation, Off-types and other relevant factor.

IV. Field Standards

A. General requirements

1. Isolation

Seed fields shall be isolated from the contaminants shown in the column 1 of the Table below by the distances specified in columns 2 and 3 of the said Table:

Contaminants	Minimum distances (meters)	
	Foundation	Certified
1	2	3
Fields of other varieties	5	5
Fields of the same variety not conforming to varietal purity requirement for certification	5	5

B. Specific requirements

Factor	Minimum distances (meters)	
	Foundation	Certified
1	2	3
*Off-types	0.10	0.20
Plants showing symptoms of mosaic	0.10	0.50
Plants infested with scale insects	None	None

Standards for Off-types shall be met at final inspection and for mosaic and plants infested with scale insects at each inspection.

Note: All off-types, diseased plants and plants infested with scale insects should be rogued out along with tubers.

V. Seed Standards

A. Specifications in respect of size and age of the planting stakes for foundation and certified classes shall be as follows:

1. Age of the crop: 7 to 12 months.
2. Diameter of the stem: 1.5 to 2.5 cm (planting stake)
3. Approximate length of the stem: 20 cm (planting stake)
4. Approximate number of nodes : 5 in the planting stake.
5. Presence of latex at the cut end of the planting stake is the indication of good quality planting material.

B. Maximum tolerance limit of planting stakes showing visible symptoms of infestation caused by scale insect will be as follows:

Factor	Maximum tolerance limit	
	Foundation	Certified
1	2	3
Planting stakes infested with scale insects	None	None

2. Seed certification standards for sweet potato (*Ipomoea batatas* (L.) Schott.)

I. Application and Amplification of General Seed Certification Standards

- A. The General Seed Certification Standards are basic and, together with the following specific standards constitute the standards for certification of sweet potato.
- B. The General Standards are amplified as follows

All certified classes shall be produced from either vine cuttings or from sprouts cut from the bed whose source and identity may be assured and approved by the Certification Agency.

II. Land Requirements

- a) Land to be used for seed production of sweet potatoes shall be free of volunteer plants.
- b) Avoid sweet potato residue and drainage from other sweet potato fields.

III. Field Inspection

A minimum of two inspections shall be made as follows:

1. The first inspection of plants bed shall be made when plants are nearly large enough to transplant;
2. The second inspection shall be made shortly after transplanting in the seed field.

IV. Field Standards

A. General requirements

1. Isolation

Seed fields shall be isolated from the contaminants shown in the column 1 of the Table below by the distances specified in columns 2 and 3 of the said Table:

Contaminants	Minimum distances (meters)	
	Foundation	Certified
1	2	3
Fields of other varieties	5	5
Fields of the same variety not conforming to varietal purity requirement for certification	5	5

B. Specific requirements

Factor	Maximum tolerance limit	
	Foundation	Certified
1		
Plant bed:		
Plants infected by		
Black rot (<i>Ceratostomella fimbriata</i> (EII. & Halst) J.A. Elliot.)	2	3
Wilt (<i>Fusarium oxysporum</i> f. <i>batatas</i> (Wr.) Snyder & Hanson)	None	None
Scurf (<i>Monilochaetes infuscans</i> (EII. & Halst) Ex. Harter	None	None
Off-types	None	None

Seed field : Plants infected by	None	None
Wilt (<i>Fusarium oxysporum</i> f.batatas (Wr.) Snyder & Hanson)	None	None
Mosaic	0.050	0.10
Off-types	0.050	0.10

*Maximum permitted at any one inspection.

Note: 1. All off-types and diseased plants should be rouged out along with root and destroyed. **V.**

Seed Standards

1. The seed material shall be reasonably clean, healthy, firm and shall confirm to the characteristics of the variety. The roots not conforming to varietal characteristics shall not exceed 0.10% and 0.20 % (by number) for foundation and certified seed classes respectively.
2. Cut, bruised, unshaped, cracked, root or those damaged by insects (except sweet potato weevil), slugs or worms shall not exceed more than 1.0% (by weight.)
3. Maximum tolerance limit of roots showing visible symptoms caused by the diseases, sweet potato weevil and other factors will be as follows

Factor	Maximum tolerance limit	
	Foundation	Certified
1	2	3
Storage rot	None	None
Black rot (<i>Ceratostomella fimbriata</i> (EII.& Halst) J.A. Elliot.)	None	None
*Scurf (<i>Monilochaetes infuscans</i> (EII. & Halst) Ex. Harter	None	None
Wilt (<i>Fusarium oxysporum</i> f. batatas (Wr.) snyder & Hanson)	None	None
Internal cork	5.0%	5.0%
Nematode	None	1.0%
Wire worm	1.0%	1.0%
Other distinguishable varieties	0.10%	0.20%
Sweet Potato weevil (<i>Cylas formicaris</i> Fab.)	None	None

* A root carrying 10.0% or above scurfed surface would be considered as one infected unit.

3.Seed certification standards for lesser yam (*Dioscorea esculenta* (Lour.) Burkill)

I. Application and Amplification of General Seed Certification Standards

The General Seed Certification Standards are basic and, together with the following specific standards constitute the standards for certification of lesser yam.

II. Land Requirements

Land to be used for seed production of lesser yam shall be free from volunteer plants. Swampy and shaded conditions may be avoided.

III. Field Inspection

A minimum of three inspections shall be made,

The first field inspection at about 90 days after planting

The second field inspection at about 150 days after planting

The third field inspection after about 200 days of planting or at appropriate growth stage depending on the crop duration of the variety concerned to verify off types and other relevant factors.

IV. Field Standards

A. General requirements

1. Isolation

Seed fields shall be isolated from the contaminants shown in the column 1 of the Table below by the distances specified in columns 2 and 3 of the said Table:

Contaminants	Maximum tolerance limit	
	Foundation	Certified
1	2	3
Fields of other varieties	5	5
Fields of the same variety not conforming to varietal purity requirements for	5	5

B. Specific requirements

Factor		
	Foundation	Certified
1	2	3
Off-types	0.050	0.10
Plants infested with scale insects	None	None

*Standards for Off-types shall be met at final inspection and for the designated insects at each inspection.

Note: 1. All Off-types and plants infested with scale insects shall be rogued out along with the tubers and destroyed

2. Gaps in the seed field shall not be more than 10.0%.

V. Seed Standards

A. Specification for Foundation and Certified classes shall be as under:

1. Seed size (weight of the tuber): 100-150 gm.

2. In a seed lot, tubers not conforming to specific size shall not exceed more than 5.0% (by number).

3. The seed material shall be reasonably clean, healthy and shall conform to the characteristics of the variety. The tubers not conforming to the varietal characteristics shall not exceed 0.050%

and 0.10% (by number) for foundation and certified seed classes respectively.

4. Cut, bruised, unshapely, cracked tubers or tubers damaged by insects (other than scale insects) slugs or worms shall not exceed more than 1.0% (by weight).

5. Maximum tolerance limit of tubers showing visible symptoms of infestation caused by scale insects will be as follows:

Factor		
	Foundation	Certified
1	2	3
Tubers infested with scale insects	None	None

4. Seed certification standards for taro (*Arvi*): *Colocasia esculenta* (L.)

I. Application and Amplification of General Seed Certification Standards

The General Seed Certification Standards are basic and, together with the following specific standards constitute the standards for certification of taro.

II. Land Requirements

1. Land to be used for seed production of taro shall be free from volunteer plants. Avoid swampy, low lying and over shaded conditions.

2. Avoid taro residue and drainage from other taro fields.

III. Field Inspection

A minimum of three inspections shall be made,

The first field inspection about 60 days after planting

The second field inspection 90 days after planting

The third field inspection about 160 days of planting and prior to harvesting or at appropriate growth stage depending on the crop duration of the variety concerned to check isolation, Off-types and other relevant factors.

IV. Field Standards

A. General requirements

1. Isolation

Seed fields shall be isolated from the contaminants shown in the column 1 of the Table below by the distances specified in columns 2 and 3 of the said Table:

Factor	Standards for each class	
	Foundation	Certified
1	2	3
Fields of other varieties	5	5
Fields of the same variety not conforming to varietal purity requirements for	5	5

B. Specific requirements

Factor	Maximum permitted (%)*	
	Foundation	Certified
1	2	3
Off-types	0.10	0.50
Plants showing symptoms of dasheen Mosaic	0.50	1.0
Plants infected by phytophthora (<i>Phytophthora colocasiae</i> (Rac.) disease	None	None
Plants infested with scale insects and mealy bugs	None	None

*Standards for Off-types shall be met at final inspection and for designated disease and insects at each inspection.

Note:

1. All Off-types, diseased and insect infested plants shall be rogued out along with corms, cormels and destroyed.
2. Gaps in the seed field shall not be more than 10.0%.

V. Seed Standards

- A. Specification in respect of size and weight of seed material for Foundation and Certified classes shall be as under:

Size of seed corms	Corresponding weight
4-6 cm x 2.5 to 3.5 cm	20-40 gm

Note:

1. In a seed lot, corms not conforming to specific size of seed shall not exceed more than 5.0% (by number)
2. The seed material shall be reasonably clean, healthy, firm and shall conform to the characteristics of the variety. The corms not conforming to varietal characteristics shall not exceed 0.10% and 0.50% (by number) for Foundation and Certified seed classes respectively
3. Cut, bruised, cracked corms or those damaged by insects (other than scale insects and mealy bugs), slugs or worms shall not exceed more than 1.0% (by weight).
4. Maximum tolerance limit of corms showing visible symptoms of infestation caused by scale insects and mealy bugs shall be as follows

Factor	Standards for each class	
	Foundation	Certified
1	2	3
Corms infested with scale insects and mealy bugs	None	None

12. SUMMARY AND RECOMMENDATIONS

There is great demand for tuber seed material and efforts should be made to meet the demand by developing a sound seed system for tropical tuber crops at national level.

For a formal seed system to be established in tropical tuber crops, the breeder (ICAR-CTCRI) should be able to supply breeder seed. Breeder seed of important crops may be made available based on realistic assessment of demand for different categories of seeds. The minimum certification standards for breeder seed should be developed, if not available already. Once breeder seed is supplied by the breeder (here CTCRI), the foundation and certified seeds are responsibilities of state governments.

First of all, identify the stages and classes of seed in respective tuber crops and develop complete SOP for certification in consultation with state agriculture departments and Seeds Division, Govt. of India. Nucleus seed or base material could be maintained *in vitro* and there should be protocol for a phased multiplication of the same.

Although stages before the breeder seed such as prebreeder seed, nucleus seed etc need attention; most important stage as far as ICR-CTCRI is concerned is breeder seed. Since, the inspection/certification at the institute is at breeder seed stage, this stage is to be clearly understood and defined. Breeder seed should undergo ELISA test and zero tolerance criteria is to be followed to ensure purity and quality of breeder seed. Traditionally in case of potato, seed tuber was indexed for virus infection but presently, TC plant (microplant) is the nucleus stock and the explants is being tested for virus. For this, TC plant should be ensured free from viruses. Mericlone and thermal/chemo therapy could be employed to clean up an already infested material.

Formal seed system could be developed only through step by step process. First develop certification standards for one crop say cassava and one variety say Sree Raksha. Cassava seed material degeneration is prevalent and hence, replacement should be done in 3-4 years. Testing procedure and the seed standards should be well defined for breeder seed of cassava. This includes the description of the material (miniset or TC plant), condition of pest/disease, procedure for testing CMD or other viruses etc. The same for other crops can be dealt subsequently.

For each crop there should be inspection team, and this team is responsible for inspection and certification. Entrust responsibility to identified scientist so that by coordinating with the team/committee a total protocol for seed standards and testing procedure are developed. The committee may decide and recommend how many generations it can go before it reaches certified or TLS. Consult state seed rolling plan of important tuber crop growing states. If not included already, try to incorporate the important crops in seed rolling plans of respective states. Before entering into SRP, we should have the standards and testing protocols ready. If there is indent based on SRP of states through DA&FW, then only it becomes formal seed system, otherwise it is only considered as voluntary system. A seed portal can be developed and hosted in the institute website for receiving seed indents, so that the requirement can be assessed and production can be regulated accordingly.

Once, the standards and testing protocols are defined, the variety may be notified so that formal system starts rolling and indents/demand will be generated.

The nodal officer should coordinate with the team in development/defining of protocols/procedures so as to notify at least four important crops say cassava, sweet potato, taro and elephant foot yam at national level.

In case of participatory seed production (semi formal) systems like DSM /seed villages, data base with geotagging is to be prepared to ensure traceability. This can be achieved by developing data base of seed producers for tuber crops and having a seed portal. Involve respective state seed certifying agencies and take up certification of DSMs. For initiating this, the crop and state must be prioritised. Buy back or price assurance is an essential step in sustaining participatory seed production such as DSM. Systems like revolving fund scheme (RFS) may be used and the institute may bear the cost of inspections till establishment of a regular seed system.

Variety licensing is a way to increase availability of seed material as well as to popularise the variety. Pricing criteria for a variety must be based on the following parameters:

- Market demand of the variety/crop
- Cost of variety development
- Number of years required/taken to develop particular variety
- Whether, it is a hybrid
- Follow non-exclusive licensing to encourage many seed producers.

The recommendations and actionable points/suggestions of the workshop are summarized below:

1. First assess the realistic demand on ground and then back calculate the requirement of certified seed, foundation seed and then breeder seed. Work out seed replacement rate of important varieties and thereby actual requirement could be arrived at.
2. Work out the realistic seed replacement rate (SRR). Between 5 to 10% should be ideal for tuber crops. Since prevalence of farmer to farmer exchange is very strong in these crops due to vegetative propagation, once 30% seed replacement is achieved, the institute /seed producing agency can withdraw, and further spread will be ensured through the farmer to farmer exchange.
3. Identify new or non traditional areas to increase the seed production and hence acreage. Eg. North Eastern states.
4. Consult seed rolling plan of respective state governments where the crops are grown in significant area and try to include major crops in it. A seed meet inviting all major stake holders could be organised at regular intervals to assess the production and demand
5. National Clean Plant Programme (CPP) of fruit crops by Govt of India could serve as a reference model for vegetatively propagated crops.

6. AICRP Centres could be entrusted with seed multiplication of locally developed varieties and other national varieties through DSM.
7. It is mandatory to multiply breeder seed at the institute/organization that developed the variety.
8. Identify state and national seed organizations for producing Foundation Seed and Certified Seeds. TFL seeds can be produced through farmers/FPO/SHG/NGO/ community groups etc.
9. Netherlands model and Scotland model could be consulted in preparing the breeder seed standards as well as testing procedures.
10. Establish an exclusive seed production team at institute level and identify and entrust a nodal officer to develop a seed system.
11. Constitute a seed certification committee at institute level for seed certification. The committee may consist of the nodal officer for seed production, a breeder, seed technologist, plant protection specialists such as entomology, pathology, virology and nematology etc. A member from the state seed certification agency could be involved in the committee for certifying foundation/certified seed production units.
12. First start with one important crop, say cassava, for preparation of breeder seed standards. Subsequently other crops may be taken up.
13. In case of the DSM or seed village system, the minimum area should be specified so as to qualify for that category.
14. Work out modalities to buyback the seed material from DSM/licensed/registered seed producers using Revolving Fund Scheme to sustain them in seed chain till a sound seed system is established.
15. Variety licensing and seed production should be aggressively pursued for spread of new/improved varieties.
16. Consider ways to reduce the volume of seed material by adopting innovative and non-conventional techniques.
17. Tissue culture and aeroponics technologies successful in potato can be adopted where ever applicable with suitable modifications.
18. Banana seed system based on embryogenic suspension culture (1 lakh plantlets developed from 1 explant) could be consulted for increasing the seed multiplication rates.
19. Apical rooted cuttings (ARC) may be considered for crops wherever its applicable.
20. Develop specialized seed transport system for each crop and type of seed material say tuber, vine, tissue culture plant etc to reduce spoilage of valuable material while transport and handling.
21. Database of all seed producers/multipliers to be prepared. It is recommended to have seed portal where seed producers, production, demand etc are mapped and the same may later be linked to national seed portal (SATHI).

Glimpses of the brainstorming workshop on seed systems in tuber crops





***Tuber Crops for
Food, Health, Wealth and Prosperity***



ICAR-Central Tuber Crops Research Institute

Sreekariyam, Thiruvananthapuram 695 017, Kerala, India

Phone: (91) (471) 2598551 to 2598554

E-mail: director.ctcri@icar.org.in

Website: <https://www.ctcri.org>

Social Media

Facebook Twitter Whatsapp Instagram You Tube

