POLICY PAPER 107

Certification of Quality Planting Material of Clonally Propagated Fruit Crops for Promoting Agricultural Diversification

NATIONAL ACADEMY OF AGRICULTURAL SCIENCES, NEW DELHI
May 2022

Certification of Quality Planting Material of Clonally Propagated Fruit Crops for Promoting Agricultural Diversification

NATIONAL ACADEMY OF AGRICULTURAL SCIENCES, NEW DELHI

May 2022

CONVENER : Dr V.K. Baranwal

REVIEWERS : Dr. S.K. Dhyani, Senior Agroforestry Specialist, World Agroforestry, ICRAF, New Delhi

Dr. S.C. Dubey, ADG, ICAR, New Delhi

EDITORS : Dr Pratap Singh Birthal and Dr Malavika Dadlani

CITATION : NAAS 2022. Certification of Quality Planting Material of Clonally Propagated Fruit Crops For Promoting Agricultural Diversification, Policy Paper No. 107, National Academy of Agricultural Sciences, New Delhi, pp 16.

Published by Executive Director on behalf of
NATIONAL ACADEMY OF AGRICULTURAL SCIENCES
NASC, Dev Prakash Shastry Marg, New Delhi-110012, India
Tel.: 011-25846051-52; Fax: 011-25846054
Email: naas-mail@naas.org.in; Website: www.naas.org.in

Preface

Fruit crops such as apple, apricot, almond, cherry, pear, peach, plum and walnut are high-value clonally propagated crops and can contribute significantly towards enhancing farmers' income. However, the productivity of most of these crops is low. The non-availability of genuine certified planting material of improved / superior fruit varieties is a major bottleneck in increasing productivity. Further, a lack of awareness and technical know-how for production of certified quality planting material also hampers increasing their productivity. In fact, diseases of clonally propagated fruit crops caused by viruses, virus-like agents and bacterial pathogens severely affect yield, appearance and taste of fruits and also plant longevity. These pathogens are often difficult to detect in propagation material, such as rootstocks and budwood, and are inadvertently taken to fields where these were not present before.

The detailed guidelines are required to ensure production and supply of certified quality planting material (CQPM) of high-value fruits crops. Realizing the need for quality planting materials of clonally propagated fruit crops to promote agricultural diversification the National Academy of Agricultural Sciences (NAAS) organized a strategy workshop on "Certification of Quality Planting Material of Clonally Propagated Fruit Crops for Promoting Agricultural Diversification" on September 20, 2021. This policy paper is an outcome of the deliberations in this workshop.

On behalf of the Academy, I compliment Prof V.K. Baranwal in bringing out recommendations for strengthening research and extension systems on CQPM. I also take this opportunity to thank Dr Pratap Singh Birthal and Dr Malavika Dadlani for their editorial support. I hope this document will be useful to the policymakers and other stakeholders.

(Trilochan Mohapatra)
President, NAAS

May 2022
New Delhi

CERTIFICATION OF QUALITY PLANTING MATERIAL OF CLONALLY PROPAGATED FRUIT CROPS FOR PROMOTING AGRICULTURAL DIVERSIFICATION

1. INTRODUCTION

India has made remarkable progress in horticultural production, reaching 330 million tonnes in 2020-21. Demand for horticultural commodities, including fruits and vegetables, has been increasing continuously, offering considerable scope for further increase in their production. Growth in production comes from an increase in area or productivity or both. Scope for growth through area expansion is limited, and the growth has to come from productivity improvements. A key constraint in raising productivity is the lack of certified quality planting material (CQPM).

India enacted the Seed Act in 1966. It helped establish seed certification agencies by the states. Amongst horticultural crops, this Act provides for the certification of the clonally propagated potato but not for other clonally propagated crops. The availability of quality seed caused a revolution — potato production increased from 4.9 million tonnes in 1973-74 to 48.7 million tonnes in 2019-20. However, the yields of most clonally propagated fruit crops are low compared to their corresponding world highest productivity (Table 1). Banana is the only fruit crop supported by the certified quality planting material under the National Certification System for Tissue Culture Raised Plants (NCS-TCP).

Fruits can contribute significantly to India's agricultural economy through exports. In 2020-21, India exported fruits, including fresh grapes, mango and walnut, worth Rs 4833.3 crores. Citrus and apple are grown in large areas throughout the country and have significant potential for exports. To harness the full potential of the clonally propagated fruit crops, efforts are needed to develop a robust system for the production of CQPM of their elite clones on indexed desirable rootstocks. This is expected to help diversify crop portfolio, conserve natural resources and increase farmers' income.

Table 1. Area and yield of important clonally propagated fruit crops in India, 2019-20

S. No.	Fruits	Area (000 ha)	Production (000 t)	Yield (t/ha)	Highest yield (t/ha)
1.	Mango	2301	20529	8.92	12.50 (Brazil)
2.	Citrus	1058	14032	13.26	27.93 (Brazil)
3.	Banana	877	31779	36.24	65.27 (Turkey)
4.	Apple	309	2783	9.01	60.05 (Switzerland)
5.	Grape	147	2939	19.99	32.64 (China)
6.	Walnut	108	287	2.66	35.20 (Romania)
7.	Pear	42	306	7.29	89.20 (Montenegro)
8.	Cherry	30	10.95	0.37	30.0 (Suriname)
9.	Peach	19	125	6.58	18.11 (Romania)
10.	Plum	23	90	3.91	49.0 (Montenegro)
11.	Almond	10	9	1.27	21.40 (Israel)
12.	Apricot	5.3	15.07	2.84	18.20 (Romania)

Source: http://www.fao.org/faostat/en/#data, http://nhb.gov.in/StatisticsViewer.aspx

2. VIRUSES AND VIRUS-LIKE PATHOGENS

Viruses and virus-like pathogens and the diseases caused by them are significant constraints in improving the productivity of clonally propagated fruit crops in India, especially apple, banana, citrus and grapes. Most of these crops are perennial in nature and harbour many viruses, viroids and phytoplasmas (Table 2). These pathogens severely affect the plants' yield, quality (appearance, taste and nutrients) and longevity, resulting in huge economic losses to their growers. Consumers are also affected by the price volatility and poor quality of fruits produced from the infected plants.

Viruses and virus-like pathogens are difficult to detect in propagation materials such as rootstocks and budwood. These are inadvertently introduced through the infected planting materials even in the areas that were earlier free from such pathogens. For example, the recent studies on virome profiling of exotic and indigenous grapevine cultivars showed many viruses not reported previously in India (Sidharthan et al., 2020). Similarly, the virome analysis of three apple cultivars has confirmed the presence of two viruses and one viroid that were not reported previously in India (Nabi et al., 2022). Such inadvertent introduction of infections can be best prevented through CQPM. Perhaps, this is the most critical factor that will contribute to raising the productivity of fruit crops and diversifying the crop portfolio. The certified superior quality materials of clonally propagated fruit crops are defined as 'the production of uniform, healthy, disease-free planting material raised through vegetative methods with an overarching goal of improving the physiological and phytosanitary quality of plants' (APAARI, 2019). Achieving this needs establishment of a national certification system.

Table 2. Important viruses and virus-like pathogens infecting clonally propagated fruit crops

Crop	Viruses	Viroids	Phytoplasma & Fastidious prokaryotes
Banana	Banana bunchy top virus (BBTV)*, banana streak viruses (BSV)*, banana bract mosaic virus (BBrMV)*, cucumber mosaic virus (CMV)*, banana mild mosaic virus (BanMMV), banana virus X (BVX) and abaca bunchy top virus (ABTV)		*Candidatus* Phytoplasma asteris, *Candidatus* Phytoplasma novig-uineense
Citrus	Indian citrus ringspot virus (ICRSV)*, citrus tristeza virus (CTV)*, citrus yellow vein clearing virus (CYVCV)*, citrus mosaic virus (CiMV)*, citrus leprosis virus (CiLV-C), citrus chlorotic dwarf-associated virus (CCDaV), citrus virus A (CiVA), citrus concave gum-associated virus (CCGaV), citrus psorosis ophiovirus (CPV), citrus vein enation virus (CVEV), citrus tatter leaf virus (CTLV), citrus leaf blotch virus (CLBV), satsuma dwarf virus (SDV), citrus variegation virus (CVV), citrus endogenous pararetrovirus (CitPRV) and gummy bark (GB)	Citrus exocortis viroid (CEVd), citrus cachexia viroid (CCaV), hop stunt viroid (HSVd)*, citrus bark cracking viroid (CBCVd), citrus dwarfing viroid (CDVd) and citrus bent leaf viroid (CBLVd)	*Candidatus* Phytoplasma cynodontis, *Candidatus* Liberibacter asiaticus, *Candidatus* Phytoplasma aurantifolia and *Candidatus* Phytoplasma asteris

Grape	Grapevine fleck virus (GFkV)*, grapevine fan leaf virus (GFLV), grapevine red blotch virus (GRBV)*, grapevine rupestris vein feathering virus (GRVFV), grapevine leaf roll associated virus (GLRaV) 1*,2,3*,4*,7, grapevine virus (GVA, B)*, grapevine rupestris stem pitting associated virus (GRSPaV)* and grapevine red globe virus (GRGV)	Grapevine yellow speckle viroid (GYSVd1*,2*), hop stunt viroid (HSVd*), Australian grapevine viroid (AGVd)*- and grapevine latent viroid (GLVd)*	*Candidatus* Phytoplasma asteris, *Candidatus* Phytoplasma solani and *Candidatus* Phytoplasma australiense
Apple	Apple mosaic virus (ApMV)*, apple necrotic mosaic virus (ApNMV), temperate fruit decay-associated virus (TFDaV), Apple chlorotic leaf spot virus (AcLSV)*, apple stem grooving virus (ASGV*), apple stem pitting virus (ASPV)*, apple green crinkle associated virus (AGCaV), cucumber mosaic virus (CMV), prunus necrotic ringspot virus (PNRSV)*, apricot latent virus(ApLV), apple rubbery wood virus (ARWV-1 & 2) and citrus concave gum-associated virus (CCGaV)	Apple scar skin viroid (ASSVd)* , apple hammerhead viroid (AHVd), apple dimple fruit viroid (ADFVd)* and apple fruit crinkle viroid (AFCVd)	*Candidatus* Phytoplasma mali and *Candidatus* Phytoplasma pruni
Almond	Apple mosaic virus (ApMV), apple chlorotic leaf spot virus (AcLSV), cherry mottle leaf virus (CMLV), prunus necrotic ringspot virus (PNRSV), and prune dwarf virus (PDV)	Peach latent mosaic viroid (PLMVd) and hop stunt viroid (HSVd)	*Candidatus* Phytoplasma phoenicium
Cherry	Cherry necrotic rusty mottle virus (CNRMV), cherry leaf roll virus (CLRV), cherry green ring mottle virus (CGRMV), cherry mottle leaf virus (CMLV), prunus necrotic ringspot virus (PNRSV), cherry little leaf virus (CLV1 & 2), cherry virus A (CVA)*, prune dwarf virus (PDV) and plum pox virus (PPV)	Hop stunt viroid (HSVd) and apple scar skin viroid (ASSVd)	*Candidatus* Phytoplasma pruni and *Candidatus* Phytoplasma asteris
Peach	Apple chlorotic leaf spot virus (AcLSV)*, plum pox virus (PPV), peach leaf pitting-associated virus (PLPaV), prune dwarf virus (PDV), prunus necrotic ringspot virus (PNRSV)*, peach virus D (PeVD) and plum bark necrosis stem pitting-associated virus (PBNSPaV)	Hop stunt viroid (HSVd) and peach latent mosaic viroid (PLMVd)	*Candidatus* Phytoplasma pruni, *Candidatus* Phytoplasma Phoenicium, *Candidatus* Phytoplasma ziziphi and *Candidatus* Phytoplasma pyri

Plum	Apple chlorotic leaf spot virus (AcLSV)*, plum pox virus (PPV)*, prune dwarf virus (PDV), prunus necrotic ringspot virus (PNRSV)*and plum bark necrosis stem pitting-associated virus (PBNSPaV)	Hop stunt viroid (HSVd) and peach latent mosaic viroid (PLMVd)	*Candidatus* Phytoplasma pruni, *Candidatus* Phytoplasma solani and *Candidatus* Phytoplasma prunorum
Pear	Apple mosaic virus (ApMV)*, temperate fruit decay-associated virus (TFDaV), apple chlorotic leaf spot virus (AcLSV)*, Apple stem grooving virus (ASGV*), apple stem pitting virus (ASPV)*, apple green crinkle associated virus (AGCaV), prunus necrotic ringspot virus (PNRSV)*, apricot latent virus (ApLV) and pear chlorotic leaf spot-associated virus (PCLSaV)	Pear blister canker viroid (PBCVd) and apple scar skin viroid (ASSVd)*	*Candidatus* Phytoplasma pyri and *Candidatus* Phytoplasma trifolii

*Pathogens reported in various vegetatively propagated fruit crops in India are marked with an asterisk

There is no scientifically documented evidence of the actual economic losses caused by graft-transmissible pathogens in fruit crops in India. However, in the USA, it has been estimated that in wine grapes, the virus-induced leaf roll disease can cause losses in the range of $25,000 to $2,26,000 per hectare over a predicted life span of 25 years of a vineyard (Almeida et al., 2013). The impact of leafroll disease in California alone is estimated at $90 million a year (Fuchs et al., 2021). Mosaic and other viruses can reduce apple yield by up to 49%. Infections of viral diseases in cherry and peach can cause yield loss up to 30% (Cembali et al., 2003). In India, the decline in citrus production is attributed to the infection of citrus tristeza virus (CTV) and huanglongbing bacterium *Candidatus* Liberibacter asiaticus (CLas). The incidence of CTV in Khasi mandarin orchards in Northeastern states has been recorded at 42-69% (Singh et al., 2017).

3. CERTIFICATION OF QUALITY PLANTING MATERIAL

The availability of quality planting material is critical to the success of horticulture developmental initiatives and the overall diversification of agriculture. It is more significant in perennial horticultural crops with a long gestation period. The available varieties of many fruit crops yield poor quality, and therefore the growers depend on imported superior exotic varieties. However, the propagation of such exotic varieties is not regulated, causing the introduction of new pathogens, especially viruses.

Many nurseries of different crops in several states have been accredited by the National Horticulture Board (NHB). Most of these nurseries have a rating below 3 on a scale of 5 (as per the accreditation criteria available at that time), indicating that these do not fulfil the requirements of CQPM, including virus testing. Testing samples of budwood source plants collected from 11 Kinnow mandarin nurseries in Punjab (rated 2 to 4 stars by NHB) indicated the presence of citrus yellow vein clearing virus, Indian citrus ringspot virus and huanglongbing-associated CLas (Pant et al., 2018). This means that farmers do not have access to good quality certified disease-free planting material of true to type varieties, resulting in poor orchard productivity and fruit quality. A recent study on seasonal dynamics of viruses in grapevine indicates a drastic decline in the copy number of viruses during December under the tropical conditions (Sidharthan, 2022), indicating criticality in the timing of virus indexing.

The unorganized private sector nurseries lack modern infrastructure, including an insect-proof greenhouse, mist chamber, efficient nursery tools, machinery and technical know-how to produce genetically-pure and pathogen-free quality planting material. Guaranteed performance in terms of higher yield and quality of crops could be achieved with reliable planting material and good management practices. There is no emphasis on monitoring quality planting material in terms of genetic makeup and trueness, varietal purity, robustness, transmissible pathogens and other pests.

3.1 CQPM: International Scenario

The citrus bud wood certification was first started in Brazil in 1921 for sweet oranges. Later, it was supported by a state decree in 1939 that established regulations for the sale of citrus trees wherein nurseries producing citrus plants were required to be obligatorily registered and periodically inspected. Since then, similar provisions have been implemented by other citrus-producing countries like Israel, France, South Africa, and the USA.

In the USA, the citrus budwood certification program was extended to all the clonally propagated crops in 2008 under the National Clean Plant Network (NCPN) to protect fruit trees, hops, grapes and other clonally propagated crops from the spread of economically harmful pests and diseases. Under NCPN, clean plant material is made available to states for the production of certified clean planting material by private nurseries and certified producers. The program is supported by a network of centers for diagnostic and pathogen elimination services to produce clean propagative plant material and maintain blocks of pathogen-tested plant material at sites across the United States. Network participation currently consists of 47 collaborating programs at 35 centres in 20 states (Fuchs et al., 2021). The centres dedicated to fruit trees are based at the Washington State University, Clemson University in South Carolina and the University of California, Davis. The centres collaborate to provide products and services needed for specialized fruit tree growing regions across the United States. Each scion or budwood source tree is identified for tracking purposes to maintain a history of test results for diseases of economic importance. Similar records are maintained for the clonally propagated rootstocks, which are tested on a random basis. To ensure that trees produced under the program remain free of virus diseases, registered scions and rootstocks are tested regularly. The intensive indexing of the scion orchards on a regular basis in the program has been instrumental in a low incidence of the diseases caused by viruses and virus-like pathogens.

South Africa has also established a similar certification program to develop seed sources for rootstocks and budwood sources to produce certified planting materials by nurseries under the ‘Superplant Scheme a (Von Broembsen and Lee, 1988).

In Europe, a unified certification system for healthy planting material of fruits was implemented in 2017 to ensure that the planting material is free from viruses and has varietal identity and homogeneity. The certification system is operated by the European & Mediterranean Plant Protection Organization (EPPO), and it is (a) based on a three-stage certification system (pre-basic, basic and certified material), (b) voluntary addition to the legally prescribed plant passport, and (c) open to all interested fruit tree nurseries. The nurseries are authorized to label the plant material with a unique quality label (https://www.eppo.int/).

In the UK, Fruit Propagation Certification Scheme (FPCS) (www.gov.uk) encourages the production and use of healthy planting stock. Commercial growers ('propagators') must join the FPCS to sell certified plants. The scheme covers soft fruits (strawberries, berry fruit and currants); tree fruits (apples, pears, cherries and plums); and *Vaccinium* shrub berries. The tissue culture raised plants of these crops are also included in FPCS. The Nuclear Stock Association (NSA) accepts varieties (candidates) from the industry for virus, disease and pest testing to meet the requirements for Pre-Basic (PB) stock as specified by the FPCS regulations. The viral pathogen, if present, is eliminated by heat treatment only after renewed testing for the viruses and a true-to-type test of the plants to be planted in the nuclear stock and used as parent material for the propagation of certified fruit trees.

3.2 Production of CQPM of Clonally Propagated Fruit Crops in India

The need to produce CQPM of clonally propagated fruit crops, particularly citrus, has been felt in India for a long (Raychaudhury and Verma, 1992). Efforts are on, but so far, these have remained in infancy. The ICAR-Central Citrus Research Institute (ICAR-CCRI) maintains mother blocks of different citrus varieties and supplies about 0.3 million indexed CQPM of Nagpur mandarin (Santara), mosambi and acid lime plant, to the growers and selected nurseries in citrus-growing states. Similarly, 1 to 4 lakhs virus-free budwood of Sathgudi sweet orange were supplied to the growers by Citrus Research Station at Tirupati from 1996 to 1999. Approximately 7-8 lakhs of planting material of Kinnow mandarin are provided every year to farmers in Punjab. Only one-fourth of it is produced and supplied by the State Agricultural University and the nurseries of the state's horticulture department. Private nurseries provide the bulk of the planting material of Kinnow mandarin to the farmers. However, there are no defined standard operating procedures for supplying certified quality planting material at any of these centres.

In pome-fruits also, there is a shortage of CQPM, as there is a huge demand to develop or convert the traditional orchards to high density under the high-density and medium-density planting schemes of the government (https://hpuniv.ac.in). The government-owned nurseries and the ICAR-Central Institute of Temperate Horticulture in Jammu and Kashmir are producing CQPM for medium-density plantations, but to a limited extent. Currently, the plants imported from Italy and other countries on M9 rootstock are being used for developing high-density apple orchards.

India has an annual requirement of nearly 200 million CQPM of clonally propagated crops; in citrus alone, almost 20 million CQPM is required (ICAR-CCRI, Nagpur). There is an urgent need to develop an efficient regulatory system to produce CQPM of clonally propagated crops. The National Horticulture Board (NHB) has put a step in this direction by accrediting many nurseries supplying plants of different fruit crops. These nurseries have to fulfil various requirements of CQPM, including virus testing (http://nhb.gov.in). But there is no organised mechanism to undertake certification of CQPM supplied by the accredited nurseries.

The country has developed a model certification system for tissue-culture plants under the Seed Act 1966. The NCS-TCP was established by the Department of Biotechnology, Government of

India, in 2006 to promote the growth of the tissue culture (TC) industry in India (Fig. 1). The main objective of the NCS-TCP is to provide certified virus-free, and true-to-type tissue culture raised plants for growers to improve the productivity of the identified crops. The program includes the fruit banana. The CQPM of bananas provided a boost to the banana industry. Banana production increased from 14.2 to 31.5 million tonnes, making India the world's largest banana producer, and raising farmers' income 5 to 6 times (APAARI, 2019).

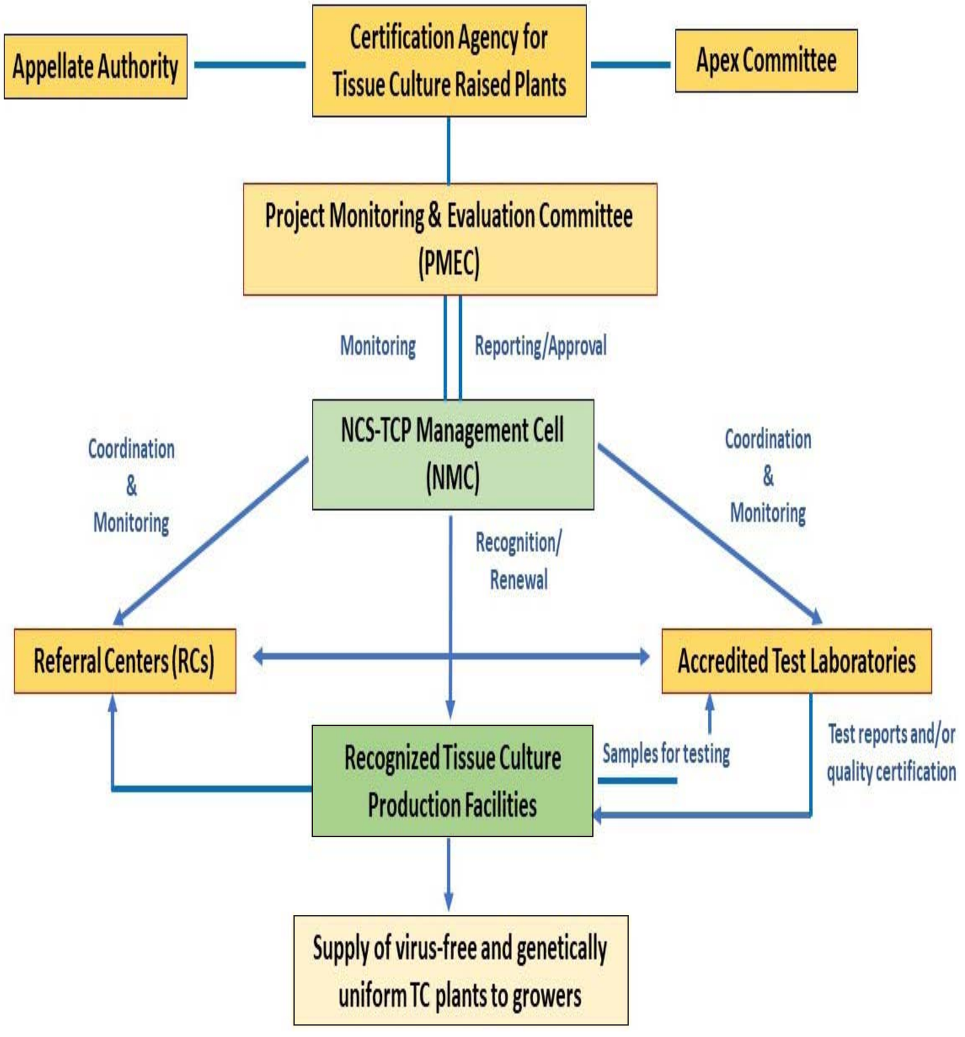

Fig. 1. Organization structure of NCS-TCP (*Source: https://dbtncstcp.nic.in/*)

The NHB regulates the accreditation of nurseries to produce planting materials for different horticultural crops, including clonally propagated fruit crops. To ensure true to type quality planting material, the NHB has set standards in terms of infrastructure, quality of seed and planting materials and adoption of nursery management practices. Based on the set guidelines for accreditation and rating of nurseries, a total of 688 nurseries across the country are accredited and rated in star ratings (1 to 3 star, as per recent guidelines) (Fig. 2).

The evaluation criteria are focussed on infrastructure for accreditation and rating of nurseries are based on different parameters like location, mother plant block attributes, propagation techniques, infrastructure, irrigation facilities, operation manuals, staff and quality, trade relations, bio-security, and disease-free conditions. Under the bio-security and disease-free conditions, the adoption of plant protection measures, condition of plants being free from disease/insect infestation, adoption of biological control and bio-safety protocol and facility/out-sourcing for virus testing are not strictly implemented for accreditation.

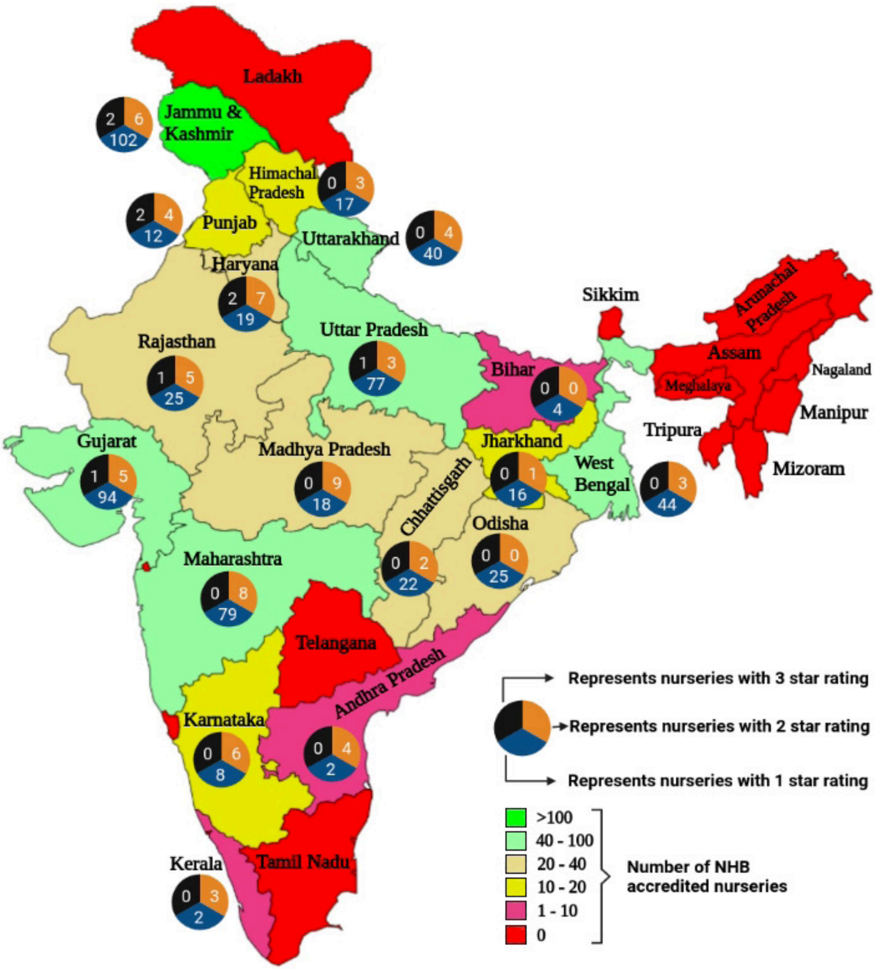

Fig. 2. Spread of NHB accredited nurseries (star rated) PAN India

A total of 31 fruit crops are covered for accreditation of nurseries (Table 3). In the set criteria for nursery accreditation, although the biosecurity and disease-free condition are mentioned, the regular indexing or testing for the clonally propagated viruses and virus-like pathogens has not been considered. It is also worth noting that out of the total 688 of the star rated nurseries across the country, only 1.31% are three-star rated, 10.61% are two-star rated, and the majority (88.08%) are one-star rated (Table 4).

Table 3. List of vegetative fruit crops and states where NHB accredited nurseries (star rated) are located

Crop	States where certified nurseries are located
Apple	Jammu & Kashmir, Uttarakhand, Himachal Pradesh, Gujarat
Acid lime	Maharashtra, Gujarat, Madhya Pradesh, West Bengal, Karnataka
Almond	Jammu & Kashmir
Propagated Apricot	Jammu & Kashmir, Uttarakhand, Himachal Pradesh
Banana	Jharkhand
Cherry	Jammu & Kashmir
Citrus	Punjab, Haryana, Maharashtra, Himachal Pradesh, West Bengal, Jammu & Kashmir, Uttarakhand, Rajasthan
Date palm	Gujarat
Dragon fruit	Gujarat, West Bengal
Fig	Maharashtra, Jammu and Kashmir, Chhattisgarh, Karnataka , Rajasthan
Grapes	Jammu and Kashmir
Kinnow	Uttar Pradesh, Punjab
Kiwi	Uttar Pradesh, Punjab
Orange	Maharashtra
Papaya	Rajasthan, Madhya Pradesh
Peach	Uttarakhand, Jammu & Kashmir, Uttar Pradesh, Punjab, Himachal Pradesh, Haryana
Pear	Jammu & Kashmir, Himachal Pradesh, Punjab, Chhattisgarh, Uttar Pradesh, Uttarakhand
Pecan	Jammu & Kashmir
Plum	Jammu & Kashmir, Uttarakhand, Uttar Pradesh, Punjab, Himachal Pradesh, Haryana
Pomegranate	Bihar, Jammu & Kashmir, Haryana, Chhattisgarh, Himachal Pradesh, Uttarakhand, Karnataka, Madhya Pradesh, West Bengal, Himachal Pradesh, Gujarat, Andhra Pradesh, Uttar Pradesh, Rajasthan, Kerala, Maharashtra
Sapota	Maharashtra, West Bengal, Karnataka, Orissa, Gujarat, Madhya Pradesh, Chhattisgarh, Kerala, Rajasthan, Jharkhand
Sweet Lime	Maharashtra, Chhattisgarh
Sweet Orange	Maharashtra, Punjab, West Bengal, Rajasthan, Madhya Pradesh, Haryana,Himachal Pradesh, Uttarakhand
Walnut	Jammu and Kashmir, Uttarakhand

Table 4 State-wise distribution of star rated nurseries as accredited by the National Horticulture Board (NHB) (as of April 2022)

S.N.	State/UT	Total Number of Nurseries	Single Star Nurseries (number)	Two Star Nurseries (number)	Three Star Nurseries (number)
1	Punjab	18	12	4	2
2	Jammu and Kashmir	110	102	6	2
3	Maharashtra	87	79	8	0
4	Uttar Pradesh	81	77	3	1
5	Odisha	25	25	0	0
6	West Bengal	47	44	3	0
7	Jharkhand	17	16	1	0
8	Himachal Pradesh	20	17	3	0
9	Haryana	28	19	7	2
10	Uttarakhand	44	40	4	0
11	Gujarat	100	94	5	1
12	Chhattisgarh	24	22	2	0
13	Rajasthan	31	25	5	1
14	Karnataka	14	8	6	0
15	Bihar	4	4	0	0
16	Madhya Pradesh	27	18	9	0
17	Andhra Pradesh	6	2	4	0
18	Kerala	5	2	3	0
Total		688	606	73	9
Share (%)			(88.1)	(10.6)	(1.3)

4. ROADMAP FOR PRODUCTION OF CPQM

The availability of genuine CQPM of fruit crops is a significant hindrance to raising production and exports. The lack of awareness and technical know-how for producing certified quality planting material and its potential discourage its adoption in the field. Farmers even purchase the planting material without considering its quality.

To achieve this, a National System on **'Certification of Quality Planting Materials – Clonally Propagated Crops' (CQPM-CPC)** may be established along the lines of the NCPN of the USA.

The key component in CQPM is the production and maintenance of virus-free source plants and their further propagation for the production of clean, healthy planting material of high quality for distribution to growers. Therefore, standard operating procedures (SOPs) need to be developed and implemented at the national level for production of clean stocks of fruit crops. The pathogen-free mother plants with good horticultural traits need to be registered with a unique identification number. Budwood should be derived from the mother plants and distributed to stakeholders such as accredited nurseries and other agencies involved in the propagation and distribution of planting material. The state of art pathogen testing laboratories at crop-based research Institutes/ universities need to be established and accredited for pathogen testing. These laboratories should be networked under the umbrella of the '**Plant Pathogen Diagnostic Network**' (**PPDN**), which should be controlled by the Indian Council of Agricultural Research (ICAR). On the lines similar to the NCS-TCP, a coordinating cell needs to be established to accredit diagnostic laboratories under the proposed PPDN. The coordinating cell may be housed at the national research institutes like ICAR-Indian Agricultural Research Institute, New Delhi. The training programs on capacity building in pathogen testing should be organised regularly for the personnel engaged in pathogen testing (viruses, virus-like pathogens, bacteria, fungi, as well as pests like scales and mites). The pathogen testing laboratories should use a standardized diagnostic protocol for selected elite planting material. In case pathogens are detected, their eradication through thermotherapy coupled with tissue culture mediated protocols or shoot-tip grafting should be undertaken, and the plants should be released only after being retested for freedom from pathogens. The program on certification of quality planting material of clonally propagated fruit crops should be funded by the Central Government to produce certified virus-free nucleus material, which can then be made available to private nurseries for propagation. The basic lab set-up of PPDN is illustrated in Fig. 3.

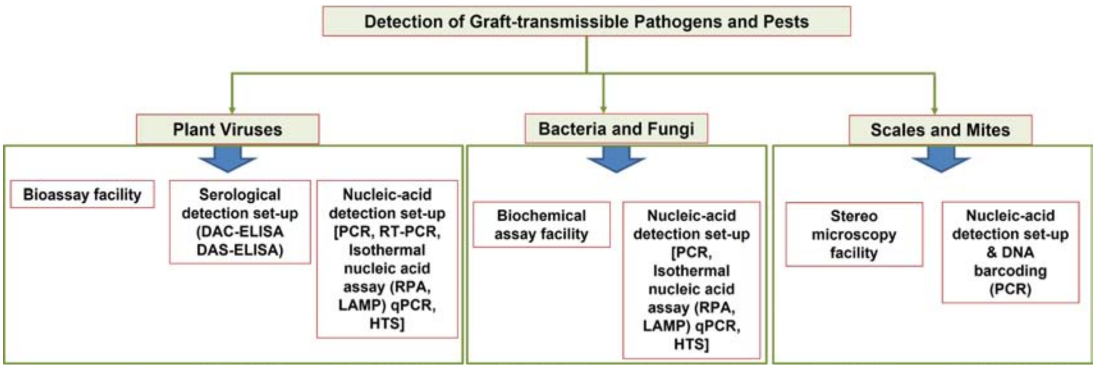

Fig. 3. The basic framework for 'Plant Pathogen Diagnostic Network' centre

The initial plant materials to be taken in CQPM-CPC could be either exotic elite materials imported through a quarantine system or domestic materials, which are extensively tested using robust standard diagnostic tools (Fig. 4). The imported exotic plant materials need to be maintained in a post-entry quarantine facility and tested through robust tools by the PPDN periodically. For testing of these materials, high-throughput sequencing (HTS by mRNAome or sRNAome) should be initially employed to detect the probable infection of any identified or unidentified virus or virus-like pathogens. The HTS will enable detecting the probable infection of all viruses and virus-like pathogens in a single limited sample without running multiple detection assays. For the HTS based virus detection, standard crop-wise assays on sampling, template preparation, HTS pipeline and *in silico* analysis pipeline should be developed and put in place. The tissues to be used for HTS analysis (targeting both RNA and DNA pathogens) are most crucial here. For this, a gold standard procedure should be developed and followed. For instance, to detect all viruses and virus-like pathogens in citrus, the mixed sample (leaf lamina and phloem tissues) could be ideal. Once HTS based testing is done, it is to be followed by standard molecular/serological tests, if required. If the plant material is tested positive, it needs to be sanitized by an appropriate method (thermotherapy, tissue culture and shoot-tip grafting) to eliminate the infection. After sanitization, the materials are to be retested for freedom from pathogens. If the planting materials are tested free from infection, they must be maintained as clean pathogen-tested certified nucleus material in the foundation block. The first stage of nucleus stock materials will be the first block (S1), which may comprise only a small number of plants, usually five to ten of each clean accession depending on the plant species. Plants in the S1 block may be maintained on an open site (only if the viruses and virus-like pathogens are not prevalent in that zone) or contained in controlled setups (greenhouses, screen houses or tissue culture). To further propagate the clean nucleus foundation plants, the plant materials from the S1 block are to be established further in fields, referred to as the S2 block, to scale up the propagating materials, which are to be taken to the growers/farmers. Depending on the bulk of clean propagating materials required, it may be further propagated in S3 and subsequently in S4 blocks (Fig. 4). The materials in the S1 block need to be maintained as 'Certified Clean Foundation Plant Stocks' at CQPM-CPC centres and the State Department of Horticulture/Agriculture. The plant materials in S2 to S4 stages may be established and maintained by the nurseries (public or private), and registration-cum-certification of these materials can be done by the State Department of Horticulture/Agriculture in collaboration with PPDN laboratories under the umbrella of CQPM-CPC (Fig. 4).

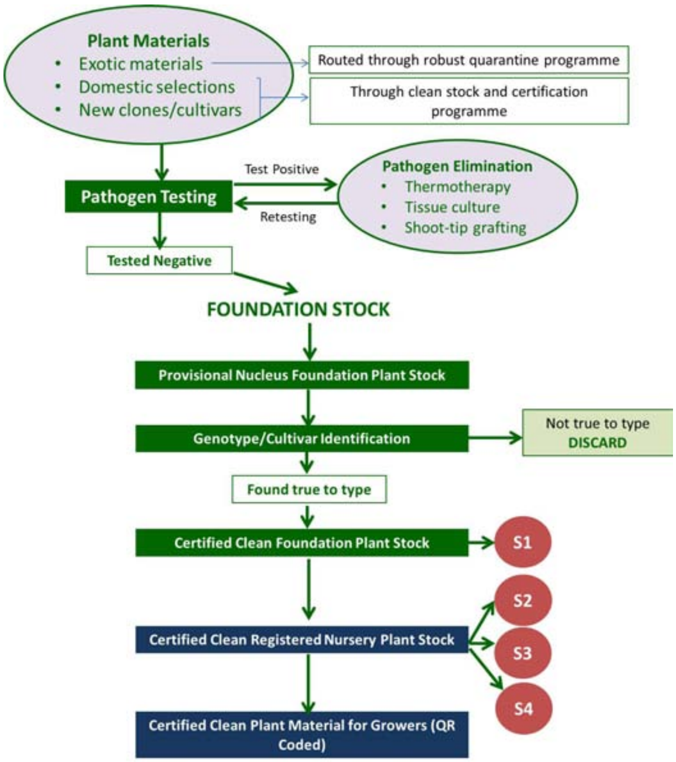

Fig. 4. Standard operating procedure for the production of quality clonally propagated fruit crop plants under the National Network on 'Certification of Quality Planting Materials – Clonally Propagated Crops' (CQPM-CPC)

All the nucleus planting materials under the ‘Certified Clean Foundation Plant Stocks’ should be maintained in an insect-free environment and be tested for important clonally transmissible and vector-transmitted pathogens at regular intervals by the PPDN laboratories. It should be mandatory to register and get the certification of S1-S4 plants for these to be free from pathogen infections. The PPDN will be responsible for developing and updating the standard testing protocol and SOP for the battery of viruses/viroids/bacteria/phytoplasma/other pathogens for each crop under the CQPM-CPC. All the foundation blocks (S1 to S4) are to be under a rigorous approach to mitigate the influx of viral pathogens through vectors to keep it clean and infection-free. As per the proposed SOP, the plants of foundation block S1 in the contained set-up after the initial rigorous testing may then be indexed once a year in case of the high prevalence of vector-transmitted viruses in the area and two years in case of the absence of vector-transmitted viruses in the area. Further, the plants of certified clean registered nursery plant stocks (S2 to S4) needs to be indexed through random stratified sampling at the rate of 0.01% in case of 100 to 10000 plant population. If tested positive at any point in time, the infected plants should be immediately removed to check the spread of pathogens. This, in addition to ensuring the healthy, clean materials in foundation blocks, will also minimize the chances of introducing regulated pathogens in S1 to S4 blocks. Before taking these fields, it must be mandatory to index the plant for all known viruses and viroids at the latest multiplication stages (S2 to S4) fields. All the certified clean plant lots produced through CQPM-CPC should be labelled with a unique bar/QR code containing information about the mother stock, quality testing attributes and genetic trueness.

5. RECOMMENDATIONS

- Farmers and growers need to be sensitized through concerned central/state government departments / institutes and extension agencies about the benefits of using certified quality planting material from registered nurseries.
- To bridge the gap between demand and availability of certified quality planting material (CQPM), an institutional mechanism needs to be developed through the entrepreneurship model supported by research institutes/universities.
- Research institutes / universities need to be supported to provide the mother stock of quality planting material and train entrepreneurs who can undertake large scale multiplication and or grafting for making CQPM available to farmers and growers.
- The foundation plant stock and subsequent clean registered plant stocks under the CQPM-CPC should be labelled with a unique identification number (bar/QR code) containing information about the mother stock, quality testing attributes and genetic trueness.
- The accreditation system of nurseries by National Horticulture Board (NHB) needs revisiting to ensure the supply of certified disease-free and true to the type planting materials.
- To ensure the production and supply of CQPM to growers, a National System on ‘Certification of Quality Planting Materials – Clonally Propagated Crops’ (CQPM-CPC) may be established as the nodal agency to oversee the planning and execution of overall certification program of all clonally propagated plants in the country.

- A ‘Plant Pathogen Diagnostic Network’ (PPDN) should be established under the aegis of CQPM-CPC by pooling the established research institutes and state agricultural universities. Crop-wise working groups may be constituted to develop guidelines for certification of pre-basic/basic material and its entire workflow in CQPM-CPC. The standard testing protocol and SOP need to be framed for economically important viruses, viroids, bacteria, phytoplasma, fungi and other pathogens/pests (scales, mites) for each fruit species.
- All the imported planting material should be adequately tested for freedom from viruses through high-throughput sequencing under post-entry quarantine (PEQ) set-up. This shall enable detection of the probable infection of any identified or unidentified viruses in a short time.

REFERENCES

Almeida, R.P.P., Daane, K.M., Bell, V.A., Blaisdell, G.K., Cooper, M.L., Herrbach, E., Pietersen, G. (2013). Ecology and management of grapevine leafroll disease. Front. Microbiol. 4:94.

APAARI. (2019). Banana Tissue Culture in India – A Success Story. Asia Pacific Association of Agricultural Research Institutions, Bangkok, Thailand, p. 43.

Cembali, T., Folwell, R.J., Wandschneider, P.R., Eastwell, K.C. (2003). Economic implications of a virus prevention program in deciduous tree fruits in the US. Crop Prot 22:1149–1156.

FAOSTAT (https://www.fao.org/faostat/en/)

Fuchs, M., Almeyda, C.V., Al Rwahnih, M., Atallah, S.S., Cieniewicz, E.J., Farrar, K., Foote, W.R., Golino, D.A., Gómez, M.I., Harper, S.J., Kelly, M.K,, Martin, RR., Martinson, T., Osman, F.M., Park, K., Scharlau, V., Smith, R., Tzanetakis, I.E., Vidalakis, G., Welliver, R. (2021). Economic studies reinforce efforts to safeguard specialty crops in the United states. Plant Dis 105:14–26. https://doi.org/10.1094/PDIS-05-20-1061-FE

Nabi, S.U., Baranwal, V.K., Rao, G.P., Mansoor, S., Vladulescu, C., Raja, W.H., Jan, B.L., Alansi, S. (2022). High-throughput RNA sequencing of mosaic infected and non-infected apple (Malus × domestica Borkh.) cultivars: From detection to the reconstruction of whole genome of viruses and viroid. Plants 2022, 11:675.

Pant, R.P., Kumar, R., Arora, A., Baranwal, V.K. (2018). Detection of Mandarivirus and greening bacterium using electron microscopy, PCR and RT-PCR in Kinnow mandarin nurseries in Punjab. Indian J Agric Sci 88(1): 86-90.

Raychaudhury, S.P., Verma, J.P. (1992). Review of Tropical Plant Pathology (Vol7). Bio-Green, India.

Sidharthan, K. (2022). Identification of Robust Approaches for Virome Analysis for Understanding the Seasonal Dynamics in Virome of Grapevines Exhibiting Leafroll (LR) Syndrome. ICAR-Indian Agricultural Research Institute. PhD Thesis, New Delhi, p. 202

Sidharthan ,V.K., Sevanthi, A.M., Jaiswal, S., Baranwal, V.K. (2020). Robust Virome Profiling and Whole Genome Reconstruction of Viruses and Viroids Enabled by Use of Available mRNA and sRNA-Seq Datasets in Grapevine (Vitis vinifera L.). Front Microbiol 11:1232. https://doi.org/10.3389/fmicb.2020.01232.

Singh, A.K., Meetei, N.T., Singh, B.K., Mandal, N. (2017). High incidence of citrus tristeza virus in mandarin (*Citrus reticulata*) in North-East states of India. Virus disease. 28(4) :401-407.

Von Broembsen, L.A., Lee, A.T.C. (1988). South Africa's citrus improvement programme. International Organization of Citrus Virologists Conference Proceedings (1957-2010) 10. https://doi.org/10.5070/C516N4C38Q.

Web Links:

http://nhb.gov.in(http://nhb.gov.in/PDFViwer.aspx?enc=3ZOO8K5CzcdC/Yq6HcdIxEAAJy972M-sano/17oFcj2o=)

https://hpuniv.ac.in/upload/uploadfiles/files/high%20density.pdf

https://www.eppo.int/

www.gov.uk/guidance/fruit-propagation-certification-scheme

LIST OF PARTICIPANTS

1. Dr. T. Mohapatra, President, NAAS and Secretary, DARE & DG, Indian Council of Agricultural Research
2. Dr. Anil K. Singh, Vice President, NAAS
3. Prof. Anupam Varma, President, World Society of Virology & Former National Professor ICAR
4. Dr. R.K. Jain, Treasurer, NAAS, Former Dean & JD (Edu.), ICAR-IARI and Emeritus Scientist, ICAR-IARI, New Delhi
5. Prof. V.K. Baranwal, National Professor, Division of Plant Pathology, ICAR-Indian Agricultural Research Institute, New Delhi
6. Dr. A. Ishwara Bhat, Principal Scientist, ICAR-Indian Institute of Spices Research, Kozhikode, Kerala
7. Dr. Anil B Patil, Sr Vice president, Jain Irrigation Systems Ltd. Jalgaon
8. Dr. B.K. Pandey, ADG (Hort.), Indian Council of Agricultural Research
9. Dr. D.K. Ghosh, Director, ICAR-CCRI, Nagpur
10. Dr. K. Gopal, Registrar, Dr Y S R Horticultural University. Venkataramannagudem (A.P.)
11. Dr. K.C. Bansal, Secretary, NAAS
12. Dr. M.K. Reddy, Head & Principal Scientist, Division of Crop Protection, ICAR-IIHR, Bangalore
13. Dr. Rashmi Aggarwal, Dean & Joint Director (Education), ICAR-IARI, New Delhi
14. Dr. S. Uma, Director, ICAR-National Research Centre for Banana, Trichy, Tamil Nadu
15. Dr. Sajad Un Nabi, Scientist, Plant Pathology, ICAR-CITH, Srinagar, J&K
16. Dr. Scott Harper, Asst professor and Director, Clean Plant Center Northwest, WSU, USA
17. Dr. Susheel Kumar Sharma, Scientist, ICAR Research Complex for NEH Region, Manipur Centre, Imphal
18. Mr. Ashutosh Sharma, CEO, Celgen Biotech, Vidisha, M.P.
19. Mr. S.K. Singh, Deputy Director, National Horticulture Board, Ministry of Agriculture & Farmers Welfare, Gurugram
20. Mr. Vinod Soni, CEO, Nishant Biotech, Bilaspur-H.P.
21. Dr. Sanjeev Saxena, Executive Director, NAAS

Note: The designations and affiliations of the participants are as on date of BSS

67. Urban and Pere-urban Agriculture -2014
68. Efficient Utilization of Phosphorus -2014
69. Carbon economy in Indian Agriculture -2014
70. MOOC for Capacity Building in Agriculture: Opportunities and Challenge -2014
71. Role of Root Entophytes in Agricultural Productivity -2014
72. Bioinformatics in Agriculture: Way Forward -2014
73. Monitoring and Evaluation of Agricultural Research, Education and Extension for Development [AREE4D] -2015
74. Bio drainage: An Eco-Friendly Tool for Combatting Waterlogging -2015
75. Linking Farmers with Markets for Inclusive Growth Indian Agriculture -2015
76. Bio-Fuels to Power Indian Agriculture -2015
77. Aquaculture Certification in India: Criteria and Implementation Plan -2015
78. Reservoir Fisheries Development in India: Management -2016
79. Integration of Medicinal and Aromatic Crop Cultivation and Value Chain Management for small Farmers -2016
80. Augmenting Forage Resources in Rural India: Policy Issues and Strategies -2016
81. Climate Resilient Livestock Production -2016
82. Breeding Policy for cattle and Buffalo in India -2016
83. Issues and Challenges in Shifting Cultivation and its Relevance in the Present Context -2016
84. Practical and Affordable Approaches for Precision in Farm Equipment and Machinery -2016
85. Hydroponic Fodder Production in India -2017
86. Mismatch Between Policies and Development Priorities in Agriculture -2017
87. Abiotic Stress Management with Focus on Drought, Food and Hailstorm -2017
88. Mitigation Land Degradation due to water Erosion -2017
89. Vertical Farming -2019
90. Zero Budget Natural Farming – A Myth or Really -2019
91. Loan Waiving Verses Income Support Schemes: Challenge and Way Forward -2019
92. Tropical Wilt Race- 4 Affecting banana Cultivation -2019
93. Enhancing Science Culture in Agriculture Research Institute -2020
94. Payment for Ecosystem Services in Agriculture -2020
95. Food-Borne Zoonotic Diseases -2020
96. Livestock Improvement Through Artificial Insemination -2020
97. Potential of Non Bovine Milk -2021
98. Agriculture and Food Policy for the Five Trillion Dollar Economy -2021
99. New Agriculture Education Policy for Reshaping India -2021
100. Strategies for Enhancing Soil Organic Carbon for Food Security and Climate Action -2021
101. Big Data Analytics in Agriculture -2021
102. WTO and Indian Agriculture: Concern and Possible Solutions -2021
103. Antimicrobial Resistance -2021
104. One World, One Health -2022
105. Sugarcane-based Ethanol Production for Sustainable Fuel Ethanol Blending Programme -2022
106. Utilization of Wastewaters in Urban and Peri-urban Agriculture -2022

Status / Strategy Papers

1. Role of Social Scientist in National Agricultural Research System (NARS) -2015
2. Toward Pulses Self-sufciency in India -2016
3. Strategy for Transformation of Indian Agriculture and Improving Farmers Welfare -2016
4. Sustaining Soybean Productivity and Production India -2017
5. Strengthening Agricultural Extension Research and Education -2017
6. Strategy on Utilization of Glauconite Mineral as Source Potassium -2017
7. Vegetable Oil Economy and Production Problems in India -2017
8. Conservation Policies for Hilsa and Mahseer -2018
9. Acceleration Seed Delivery Systems for Priming Indian Farm Productivity Enhancement: A Strategic Viewpoint -2018
10. Renewable Energy: A New Paradigm for Growth in Agriculture -2018
11. Rumen Microbiome and Amelioration of Methane Production -2019
12. Harnessing Full Potential of A1 and A2 Milk in India: An Update -2019
13. Development and Adoption of Novel Fertilizer Materials -2019
14. Innovation in Potato Seed Production -2021

Police Briefs

1. To Accelerate Utilization of GE Technology for Food & Nutrition Security and Improving Farmers' Income -2016
2. Innovative Viable Solution to Rice Residue Burning in Rice-Wheat Cropping System through Concurrent Use of Super Straw Management System-fted Combines and Turbo Happy Seeder -2017
3. Soil Health: New Policy Initiative for Farmers Welfare -2018
4. Uniform Policy for Fish Diseases Diagnosis and Quarantine -2019
5. Saving the Harvest: Reducing the Food Loss and Waste -2019
6. Better Management of Pesticides in India: Policy Perspective -2019
7. Regulatory Framework for Genome Edited Plants: Accelerating the pace Precision of Plant Breeding -2020
8. Covid-19 pandemic : Impact and New Normal in Agriculture -2020
9. Direct Benefit Transfer of Fertilizer Subsidy: Policy Perspectives -2020
10. Harmonization of Seed Regulation for Sustainable Food Security in India -2020
11. Towards Revision of Biological Diversity Act 2002 -2021

NAAS DOCUMENT ON POLICY ISSUES*

1. Agricultural Scientist's Perception on National Water Policy -1995
2. Fertilizer Policy Issues (2000-2025) -1997
3. Harnessing and Management of Water Resources for Enhancing Agricultural Production in the eastern Region -1998
4. Conservation, Management and use of Agro-biodiversity -1998
5. Sustainable Agricultural Export -1999
6. Reorienting Land Grant System of Agricultural Education in India -1999
7. Diversification of Agriculture for Human Nutrition -2001
8. Sustainable Fisheries and Aquaculture for Nutritional Security -2001
9. Strategies for Agricultural Research in the North-East -2001
10. Globalisation of Agriculture: R & D in the India -2001
11. Empowerment of Western in Agriculture 2001
12. Sanitary and Phytosanitary Agreement of the World Trade Organization- Advantage India -2001
13. Hi-Tech Horticulture in India - -2001
14. Conservation and Management of Genetics Resources of Livestock -2001
15. Prioritization of Agricultural Research -2001
16. Agriculture-Industry Interface: Value Added Farm Products -2002
17. Scientists' Views on Good Governance of An Agricultural Research Organization -2002
18. Agricultural Policy: Redesigning R & D to Achieve it's Objectives -2002
19. Intellectual Property Right in Agriculture -2003
20. Dichotomy Between Grain Surplus and Widespread Endemic Hunger -2003
21. Priorities of Research and Human Resources Development in Fisheries Biotechnology -2003
22. Seaweed Cultivation and Utilization -2003
23. Export Potential of Dairy Products -2003
24. Biosafety of Transgenic Rice -2003
25. Stakeholders' Perceptions on Employment Oriented Agricultural Education -2004
26. Peri-Urban Vegetable Cultivation in the NCR DELHI -2004
27. Disaster Management in Agriculture -2004
28. Impact of Inter River basin Linkages on Fisheries -2004
29. Transgenic Crops and Biosafety Issues Related to Their Commercialization in India -2004
30. Organic Farming: Approaches and Possibilities in the Context of Indian Agriculture -2005
31. Redefining Agricultural Education and Extension and System in Changed Scenario -2005
32. Emerging Issues in Water Management- The Question of Ownership -2005
33. Policy Options for Efficient Nitrogen Use -2005
34. Guidelines for Improving Quality of Indian Journal & Professional Societies in Agriculture and Allied Science -2006
35. Low and Declining Crop Response to Fertilizers -2006
36. Belowground Biodiversity in Relation to Cropping System -2006
37. Employment Opportunities in Farm and Non Sectors Through Technological Intervention with Emphasis on Primary Value Addition -2006
38. WTO and Indian Agriculture: Implications for Policy and R&D -2006
39. Innovation in Rural institutions : Driver for Agricultural Prosperity -2007
40. High Value Agriculture in India: Prospects and Policies -2008
41. Sustainable Energy for Rural India -2008
42. Crop Response and Nutrition Ratio -2009
43. Antibiotics in manure and Soil- A grave Threat to Human and Animal Health -2010
44. Plant Quarantine Including Internal Quarantine Strategies in View of Onslaught of Diseases and Inspect Pests -2010
45. Agrochemical Management: Issues and Strategies -2010
46. Veterinary vaccines and Diagnostics -2010
47. Protected Agriculture in North-West Himalayas -2010
48. Exploring Untapped Potential of Acid Soils of India -2010
49. Agricultural Waste Management -2010
50. Drought Preparedness and Mitigation -2011
51. Carrying Capacity of Indian Agriculture -2011
52. Biosafety Assurance for GM food Crops in India -2011
53. Eco labelling and Certification in Capture Fisheries and Aquaculture -2012
54. Integration of Millets in Fortified Foods -2012
55. Fighting Child Malnutrition -2012
56. Sustaining Agriculture Productivity Through Integrated Soil Management -2012
57. Value Added Fertilizers and Site Specific Nutrient Management (SSNM) -2012
58. Management of Crop Residues in the Context of Conservation Agriculture -2012
59. Livestock Infertility and its Management -2013
60. Water Use Potential of Flood- affected and Drought-Prone Areas of Eastern India -2013
61. Mastitis Management in Dairy animals -2013
62. Bio pesticides – Quality Assurance -2014
63. Nanotechnology in Agriculture: Scope and Current relevance -2014
64. improving Productivity of Rice Fallows -2014
65. Climate Resilient Agriculture in India -2014
66. Role of Millets in Nutritional Security of India -2014

For detail visit web site: http://naas.org.in

Continued on inside cover