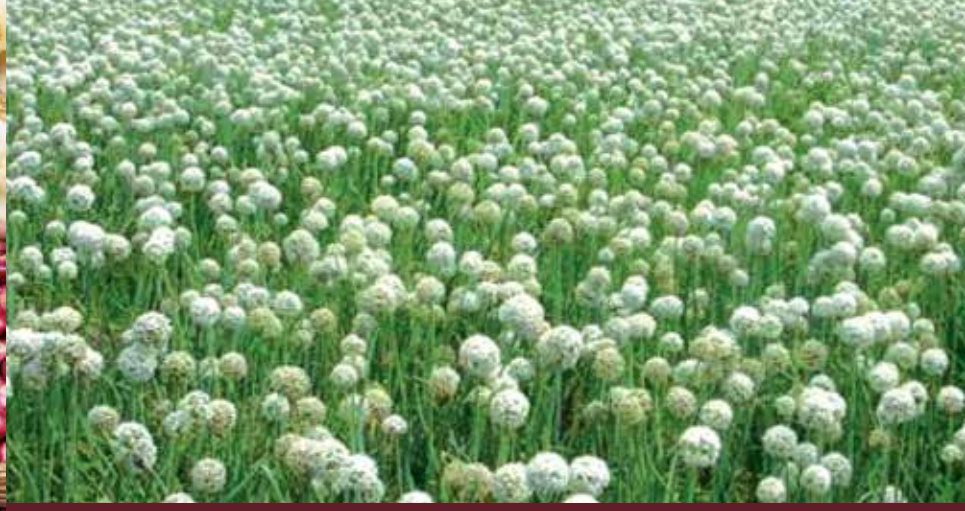

National Seminar on Strategic Management of Production & Post–Harvest Technologies of Onion, Garlic & Potato for Uplifting the Livelihood of Farmers

11-12 March, 2019 at
Dr. B.P. Pal Auditorium, ICAR-IARI,
Pusa, New Delhi

Souvenir

बागवानी मिशन
Horticulture Mission

Organized by

National Horticultural Research and Development Foundation
Division of Vegetable Science, ICARI-IARI, Pusa New Delhi

Souvenir

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Strategic Management of Production & Post-Harvest Technologies of Onion, Garlic & Potato for Uplifting the Livelihood of Farmers

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Horticulture Mission

***Organized by*:**

National Horticultural Research and Development Foundation
Division of Vegetable Science, ICARI-IARI, Pusa New Delhi

Citation : **National Seminar – *Souvenir***
National Horticultural Research and Development Foundation,
New Delhi - 110058

Published by : **Dr. P.K. Gupta**
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Year of Publication : March, 2019

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No. of copies : 300

Cover photos : Garlic, Onion, Potato and Onion Seed Crop

Designed and Printed at : **Malhotra Publishing House**
B-6, DSIDC Complex, Kirti Nagar, New Delhi - 110 015
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Message

Onion, garlic and potato being important horticultural crops contribute significantly to socio-economics in the country. These crops are grown by small and marginal farmers across the country. Although, there has been substantial improvement in production due to technology related inventions from time to time, there is ample scope for increasing production to meet the domestic and export demands of the country. Price of these commodities is also fluctuating disproportionally putting stress both on consumers and growers. Availability of quality seed, adoption of improved production technologies, efficient post-harvest management and delivery systems are major issues, which shall determine the satisfaction of consumers and growers. Thus, these issues are required to be addressed in a strategic manner to develop a mechanism to avoid shortage and surplus and encourage the export. Organizing the National Seminar on **"Strategic management of Production & Post-Harvest Technologies of Onion, Garlic & Potato for Uplifting the Livelihood of Farmers"** by the National Horticultural Research & Development Foundation (NHRDF) on 11th and 12th March, 2019. The theme of accelerated production and quality to help farmers for doubling their income also to help export of onion and garlic is timely.

I wish the Seminar a grand success and compliment the employees of the NHRDF for their efforts and enthusiasm for organizing on National Seminar and bring out this publication for the benefit of onion, garlic and potato growers and other stakeholders in the country.

Date: 8 March, 2019

(Dr. Bijender Singh)

त्रिलोचन महापात्र, पीएच.डी.
एफ एन ए, एफ एन ए एस सी, एफ एन ए ए एस
सचिव एवं महानिदेशक
TRILOCHAN MOHAPATRA, Ph.D.
FNA, FNASc, FNAAS
SECRETARY & DIRECTOR GENERAL

भारत सरकार
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MESSAGE

I am happy to learn that the National Horticultural Research and Development Foundation (NHRDF) and the Division of Vegetable Science, ICAR-IARI, New Delhi are jointly organizing a National Seminar on **"Strategic Management of Production and Post–Harvest Technologies of Onion, Garlic and Potato for Uplifting the Livelihood of Farmers"** on 11th to 12thMarch, 2019 at IARI, New Delhi under the MIDH Scheme of Department of Agriculture Cooperation and Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Govt. of India.

I am sure that the seminar would provide a valuable opportunity for the horticulture scientists to share their knowledge and experience and evolve improved and pragmatic approaches for achieving sustained growth of the horticulture sector especially onion, garlic and potato crops. I trust that the seminar shall also consider formulating viable action plan for optimally utilizing technological innovations and the latest know-how for achieving increased production and productivity of these important crops and allied sectors, which would contribute to the rapid socio-economic development of the country especially small and marginal farmers.

I wish the National Seminar a great success.

(T. MOHAPATRA)

Dated the 8th March, 2019
New Delhi

अशोक दलवाई, भा.प्र.से.
मुख्य कार्यकारी अधिकारी
भारत सरकार,
कृषि एवं किसान कल्याण मंत्रालय
कृषि, सहकारिता एवं किसान कल्याण विभाग
राष्ट्रीय वर्षा सिंचित क्षेत्र प्राधिकरण

सत्यमेव जयते

ASHOK DALWAI, IAS
Chief Executive Officer
Government of India,
Ministry of Agriculture and Farmers Welfare
Department of Agriculture, Cooperation & Farmers Welfare
National Rainfed Area Authority (NRAA)

MESSAGE

I am happy that the National Horticultural Research and Development Foundation (NHRDF), and the Division of Vegetable Science, ICAR-IARI Pusa, New Delhi are jointly organizing a national seminar at New Delhi. The theme, **"Strategic Management of Production & Post-Harvest Technology of Onion, Garlic & Potato for Uplifting the Livelihood of Farmers"** is important. The timing of the seminar, dated 11th and 12th of March, 2019 is also appropriate.

All these three crops – onion, garlic and potato are important components of an Indian farmer's cropping system, while also being essential ingredient in the consumers' cuisine. While their prices impact the family's consumption budget, the farmer's income is influenced by the price they fetch in the market. While there is an apparent conflict in the respective interests of the producer and the consumer, it is possible to reconcile the two.

Suitable technology that will enable to scale up the productivity, coupled with robust storage and transportation systems can ensure the desired supply chain throughout the year, to the satisfaction of the consumers. Once supply and demand are managed by way of proper agri-logistics and efficient marketing system, price equilibrium at a reasonable level and to the satisfaction of both consumers and producers can be achieved. The Government has rolled out 'Operation Greens' covering tomato, onion and potato to address the historical price fluctuations.

Our farmers need to be supported to realize higher net profits from cultivation of various crops including onion, potato and garlic by offering them an efficient package of technology. The important features needed are high productivity, low cost of production, resource use efficiency, resistance of vagaries of nature and pests & diseases, and longer shelf life. Low cost storage technology is also needed.

I am sure, that the scientists, academics, and others at the seminar will put their thoughts together to offer us a wholesome cafeteria of recommendations, that can be translated into suitable policies and programmes.

My best wishes for success of the national seminar.

A Dalwai 07/03/2019
(ASHOK DALWAI)

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डा. अशोक कुमार सिंह
उप महानिदेशक (कृषि प्रसार)
Dr. A.K. Singh
Deputy Director General (Agricultural Extension)

Message

I am pleased to learn that the National Horticultural Research and Development Foundation (NHRDF) and the Division of Vegetable Science, ICAR-IARI Pusa, New Delhi are jointly organizing a National Seminar on **"Strategic Management of Production & Post–Harvest Technologies of Onion, Garlic & Potato for Uplifting the Livelihood of Farmers"** on 11th & 12th March, 2019 at IARI, Pusa, New Delhi under the MIDH Scheme of Dept. of Agril., Co-op. & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Govt. of India.

Varietal improvement, technological enhancement in production and quality seed production are the issues requiring continuous attention. It is high time to replace the local poor yielding varieties with improved high yielding and good storable varieties. I hope, the scientists will address these issues during the discussions on Production & Post-Harvest Technologies of Onion, Garlic & Potato for uplifting the livelihood of farmers and come up with suitable strategies.

I am sure that the seminar will serve as a platform for evolving broad consensus on use of smart technologies and development of future strategies. This will help in boosting farm profitability and socio-economic status of farmers engaged in horticulture and allied sectors.

I extend my best wishes for success of the seminar.

Dated : 5th March, 2019

(A.K.Singh)

अश्वनी कुमार
संयुक्त सचिव
भारत सरकार
कृषि एवं किसान कल्याण मंत्रालय
कृषि, सहकारिता एवं किसान कल्याण विभाग
कृषि भवन, नई दिल्ली-110001

सत्यमेव जयते

Ashwani Kumar
Joint Secretary
Government of India
Ministry of Agriculture & Farmers Welfare
Department of Agriculture, Cooperation
and Farmers Welfare
Krishi Bhawan, New Delhi-110001

Message

India has varied agro-climatic conditions making the cultivation of whole range of vegetables possible in one or other part of the country. The important vegetables crops grown in our country are onion, potato, tomato, brinjal, peas, beans, okra, chilli, cabbage, cauliflower, pumpkin, bottle gourd, bitter gourd, pointed gourd, cucumber, muskmelon, water melon, radish, carrot, spinach and fenugreek. Out of these, onion, garlic & potato are the most important vegetable crops grown and consumed in almost all the states.

Seed is one of the most important determinants of the future plant development. The efficacy of other agricultural inputs is largely determined by the quality of seed, which accounts for twenty to twenty five percent of productivity. Assuring quality seed is thus imperative for us to increase food production and ensuring food security. In the past decades, the seed sector has not only played an important role in achieving national food security but also in improving the livelihood of Indian farmers. In the present scenario of population growth and climate uncertainties, the challenges confronting the seed sector are greater than ever before with an emphasis of spreading new plant varieties and enhancing the Seed Replacement Rate to sustain national food security in the coming decades. Varietal improvement, technological enhancement in production and quality seed production are the issues requiring continuous attention. It is high time to replace the local poor yielding varieties with improved high yielding and good storable varieties.

I am happy to know that the National Horticultural Research and Development Foundation (NHRDF) and the Division of Vegetable Science, Indian Agricultural Research Institute, Pusa, New Delhi are jointly organizing a National Seminar on "**Strategic Management of Production & Post-Harvest Technologies of Onion, Garlic & Potato for Uplifting the Livelihood of Farmers"** on 11th & 12th March, 2019 at IARI, Pusa, New Delhi under the Mission for Integrated Development of Horticulture Scheme of Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India.

I firmly hope that this National Seminar will provide opportunities to scientists for discussion on these issues and come up with suitable strategies.

I wish the National Seminar a grand success.

(Ashwani Kumar)

Santosh Kumar Sarangi
Joint Secretary
Email: santosh.sarangi@nic.in
Telfax: 23061818

भारत सरकार
वाणिज्य एवं उद्योग मंत्रालय
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Government of India
Ministry of Commerce & Industry
Department of Commerce
Udyog Bhawan, New Delhi-110011
http://commerce.gov.in

MESSAGE

Onion, garlic and potato are widely grown and consumed vegetable crops in India with high nutritional and medicinal properties. Besides fulfilling the domestic demand, they also have huge export potential. Production of onion, garlic & potato is high in India that makes the country second largest producer worldwide next to China. There is an urgent need to increase the productivity and also to reduce post-harvest-losses in order to stabilize the market prices.

I am glad to know that the National Horticultural Research and Development Foundation and the Division of Vegetable Science, ICAR-IARI Pusa, New Delhi are jointly organizing a National Seminar on **"Strategic Management of Production & Post–Harvest Technologies of Onion, Garlic & Potato for Uplifting the Livelihood of Farmers"** on 11th& 12th March, 2019 at IARI, Pusa, New Delhi under the MIDH Scheme of Dept. of Agril., Co-op. & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Govt. of India to discuss the issues related to onion, garlic and potato crops.

I am happy to share that in the recently announced Agriculture Export Policy (AEP), onion clusters are planned in Nashik, Maharashtra and in Karnataka. It is expected that exports from these regions would increase substantially. It would be highly appreciated if this platform is used for highlighting the merits/advantages that may accrue from AEP before all the attendees, especially farmers, as it has been formulated in line with the vision of Hon'ble Prime Minister to double the farmer's income.

I wish the Seminar all the success.

(Santosh Kumar Sarangi)

Dr. S.K. Malhotra
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सत्यमेव जयते

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कृषि, सहकारिता एवं किसान कल्याण विभाग
कृषि भवन, नई दिल्ली-110001
Government of India
Ministry of Agriculture & Farmers Welfare
Department of Agriculture, Cooperation & Farmers Welfare
Krishi Bhawan, New Delhi-110001

Dated: 6th March, 2019

MESSAGE

I am happy to know that the National Horticultural Research and Development Foundation (NHRDF) and Division of Vegetable Science, ICAR-IARI are jointly organizing a National Level Seminar on **"Strategic Management of Production & Post–Harvest Technologies of Onion, Garlic & Potato for Uplifting the Livelihood of Farmers" from 11-12, March, 2019** at ICAR-IARI, Pusa, New Delhi.

Vegetables occupy an important place in diversification of agriculture and provide high economic returns to the farmers. Research and Development efforts by Government of India through Mission for Integrated Development of Horticulture and National Agricultural Research System improved the production and availability of nutritious vegetables. In order to give filip to these crops Government started operation green. But the productivity is still low for many vegetable crops. In the emerging scenario of climate change and challenge of feeding growing population with declining land and water, strategic management of production and post harvest technologies is important to uplift the livelihood of farmers.

I am sure this platform will address the issues and come up with concrete strategies for future advancement of high demanded crops for enhancing the farmers income.

I wish a grand success in this endeavour.

6.3.19

(S.K.Malhotra)

Dr. B.N. Srinivasa Murthy
Horticulture Commissioner

Government of India
Ministry of Agriculture and Farmers Welfare
Deptt. of Agriculture, Cooperation and Farmers Welfare,
Krishi Bhawan, New Delhi-110001

Dated: 25th February 2019

Message

It is a matter of great pleasure for me that the National Horticultural Research and Development Foundation (NHRDF) and the Division of Vegetable Science, ICAR-IARI Pusa, New Delhi are jointly organizing a National Seminar on **"Strategic Management of Production & Post-Harvest Technologies of Onion, Garlic & Potato for Uplifting the Livelihood of Farmers"** on 11th & 12th March, 2019 at IARI, Pusa, New Delhi under the MIDH Scheme of Dept. of Agril., Co-op. & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Govt. of India.

The NHRDF has developed good onion & garlic varieties suitable for different seasons as well as for storage. However, there is need to replace the seeds of local varieties with the improved and high yielding varieties to increase the productivity. The recent approach of the government to bring in higher money share to the farmers that the consumer pays for the product he buys and to develop cluster approach in production is essential. Keeping in view the importance of the onion, garlic and potato crops in the country amongst the poor to rich families, the present seminar is the right platform to discuss the strategies for the same and make suitable recommendations for the development of onion, garlic and potato varieties.

I congratulate the NHRDF & the Division of Vegetable Science, ICAR-IARI, New Delhi for organizing this National Seminar.

I wish the National Seminar a grand success.

(Dr. B.N.S. Murthy)

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डॉ. सुशील कुमार सिंह
निदेशक
Dr. Sushil Kumar Singh
Director

Date: 08th March, 2019

MESSAGE

I am glad that the National Horticultural Research and Development Foundation (NHRDF) and the Division of Vegetable Science, ICAR-IARI, Pusa, New Delhi are jointly organizing a National Seminar on **"Strategic Management of Production & Post–Harvest Technologies of Onion, Garlic & Potato for Uplifting the Livelihood of Farmers"** on 11th & 12th March, 2019 at IARI, Pusa, New Delhi under the MIDH Scheme of Department of Agricultural Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Govt. of India.

Under the Mission for Integrated Development of Horticulture (MIDH) Scheme, assistance is being extended for vegetable seed production, including onion, through the public and private sectors. The NHRDF, NSC and SFCI are also involved as National Level Agencies (NLA) for vegetable seed production. However, only about 20% of the total seed requirement of onion is met through the organized sector having quality assurance mechanism. There is, therefore, an urgent need to generate awareness about quality seed production and other technological developments in onion production.

I compliment to NHRDF for taking initiative in organizing this National Level Seminar and bringing out a souvenir to mark the occasion. I am confident that this initiative would provide a platform for the participating scientists and seed producing companies to discuss important issues of concern i.e. onion, garlic & potato crops.

I wish the organizers all the success.

(S.K. SINGH)

Foreword

The National Horticultural Research and Development Foundation (NHRDF), New Delhi in collaboration with the Division of Vegetable Science, ICAR-IARI, Pusa, New Delhi is organising a National Seminar on **"Strategic Management of Production & Post-Harvest Technologies of Onion, Garlic & Potato for Uplifting the Livelihood of Farmers"** on **11th & 12th March, 2019** at Dr. B.P. Pal Auditorium, ICAR-IARI, Pusa, New Delhi under the "Mission for Integrated Development of Horticulture" (MIDH) Scheme of the Dept. of Agriculture, Co-op. & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Govt. of India.

The topic of this National Seminar is designed seeing the present scenario of the horticultural crops in the country. These crops are very important for the nation because without these vegetables no daily diet is complete. Onion is the major vegetable crop earning more foreign exchange for the country.

The NHRDF is a pioneer institute to start R&D work on onion and garlic crops in the country. It has developed 18 varieties of garlic and 12 varieties of onion. It has not only developed the varieties but it is also maintaining seed chain on regular basis under the MIDH and providing quality seed / planting material to growers in the country.

I am sure, this seminar will definitely provide a forum for the farmers, scientists, students, policy makers, traders, seeds men, Govt. Authorities of the concerned Departments to discuss about the issues related to these crops and share their views on the recent development, future challenges and mitigation strategies for uplifting the livelihood of the farming community of the nation. This seminar is arranged on 5 different themes. About 25 scientific lectures will be delivered and problems of the farmers will be solved by the scientists during the two days sessions.

I hope the scientists will address the issues and future challenges during the discussions and make valuable recommendations by considering the inputs received from different stakeholders to make future strategies.

I wish the seminar a grand success.

Date: 08/03/2019

(Dr. P.K. Gupta)
Director, NHRDF

Technical Programme

11th March, 2019 (Monday)

09.30-10.45 hrs - **Registration**

10.45-12.00 hrs. - Inaugural Session

12.00-12.30 hrs - ***Inaugural Tea***

12.30-14.30 hrs - **Technical Session-I**
(Innovative Production Technologies of Onion & Garlic)

14.30-15.00 hrs - ***Lunch***

15.00-17.00 hrs - **Technical Session-II**
(New Production Technologies of Potato)

12th March, 2019 (Tuesday)

10.00-11.30 hrs - **Technical Session-III**
(Strategic Management of Post-Harvest Technologies of Onion, Garlic & Potato and their Export Potential)

11.30-12.30 hrs - **Technical Session-IV**
(Role of Govt. Schemes in Uplifting Livelihood of Farmers through Horticultural Crops)

12.30-14.30 hrs - **Technical Session-V**
(Peri-Urban Horticulture: Opportunities & Challenges)

14.30-15.00 hrs - ***Lunch***

15.00-16.00 hrs - **Plenary Session and Closing Ceremony**

Technical Session-I : Innovative Production Technologies of Onion & Garlic

***Date*:** 11th March, 2019 (Monday) ***Time*:** 12.30-14.30 hrs

***Chairman* : Dr. A.K Singh,** Dy. Director General (Hort. & Crop Science), ICAR, New Delhi

***Co-Chairman* : Dr. B.N.S. Murthy**, Horticulture Commissioner, MOA&FW, GOI
Dr. R.P. Gupta, Ex-Director, NHRDF & Chief Consultant, MIDH., GOI

***Convener* : Dr. Harshwardhan Choudhary**, P.S, Div. of Veg. Science, IARI, New Delhi
Dr. S.K. Tiwari, Sr. Tech. Officer (Seed), NHRDF, New Delhi

Theme of Presentation	Speaker
(a) Present Scenario in onion and garlic in the country	Dr. R.P. Gupta, Ex-Director, NHRDF & Chief Consultant, MIDH. GOI
(b) Challenges & opportunities in hybrid onion production in India	Dr. Anil Khar, Principal Scientist, Div. of Veg. Science, ICAR-IARI, New Delhi
(c) Innovative Production Technologies of onion and garlic in India	Sh. H.K. Sharma, Dy. Director (Seed), NHRDF, Delhi
(d) Hybrid Seed Production Technology in Vegetable	Dr. B.S. Tomar, Head, Div. of Veg. Science, ICAR-IARI, New Delhi
(e) Development and Scope of Quality Seed Production in Vegetable Crops	Dr. L.K. Pandey, Ananay Seeds, New Delhi

Technical Session-II : New Production Technologies of Potato

***Date*:** 11th March, 2019 (Monday) ***Time*:** 15:00-17:00 hrs

***Chairman* : Dr. N.K. Krishna Kumar**, Ex-DDG (Horticulture), ICAR, Bangalore

***Co-Chairman* : Dr. S.K. Chakrabarti**, Director, ICAR-CPRI, Shimla
Dr. B.S. Tomar, Head, Division of Vegetable Science, ICAR-IARI, New Delhi

***Convener* : Dr. Manoj Kumar**, Joint Director, CPRI, Modipuram
Sh. H.K. Sharma, Dy. Director (Seed), NHRDF, New Delhi

Theme of Presentation	Speaker
(a) Overview of Potato Production in the country	Dr. S.K. Chakrabarti, Director, ICAR-CPRI, Shimla (HP)
(b) New Technologies for Quality Seed Production of Potato	Dr. Manoj Kumar, Joint Director, ICAR-CPRI, Modipuram, Meerut (UP).

(c) Present demand of Industries-Process varieties of potato	Dr. S.K. Luthra, Prin. Scientist, ICAR-CPRI, Modipuram, Meerut (UP)
(d) New paradigm of Plant Protection measure of potato	Dr. (Mrs) Kamlesh Malik, Principal Scientist, ICAR-CPRI, Modipuram, Meerut (UP)

Technical Session-III : Strategic Management of Post-Harvest Technologies of Onion, Garlic & Potato and their Export Potential

***Date*:** 12th March, 2019 (Tuesday) ***Time*:** 10:00-11:30 hrs

***Chairman* : Dr. H.P. Singh**, Ex-DDG (HS), ICAR & Chairman, CHAI, New Delhi

***Co-Chairman* : Dr. V.R. Sagar**, Head, Food Science & PHT, ICAR-IARI, Pusa, New Delhi
Shri Lallan Singh, Ex-Addl. Director, NHRDF, New Delhi

***Conveyer* : Dr. Ram Ashray**, Prin. Scientist, Div. of PHT., ICAR-IARI, New Delhi
Dr. Anil Khar, P.S, Div. of Veg. Science, IARI, Pusa, New Delhi

Theme of Presentation	Speaker
(a) An industry of overview-Scenario of Post-Harvest Management of Potato	Dr. Tej Pal Singh Tomar, General Manager, M/s Merino Pvt.Ltd, Hapur
(b) Export potential of dehydrated product of onion, garlic & potato	Dr. Vineeta Sidhansu, DGM, APEDA, New Delhi
(c) New Technologies /Machinery for Post-Harvest Management of onion & garlic	Dr. V.D. Mudgal, Ex-Prof. & P.I., ICAR-AIPHT, MPGA&T, Udaipur
(d) Process products & their nutritive value of onion, garlic & potato and important for food diet	Dr. V.R. Sagar, Head, PHT, ICAR-IARI, Pusa, New Delhi
(e) Value-Chain Management of Potato through contract farming-Field to Fork	Dr. Santosh Kumar Tiwari, M/s Pepsico, Gurgaon

Technical Session-IV : Role of Govt. Scheme in uplifting the Livelihood of Farmers through Horticulture Crops

***Date*:** 12th March, 2019 (Tuesday) ***Time*:** 11.30-12.30 hrs

***Chairman* : Dr. S.K. Malhotra**, Agriculture Commissioner, MOA&FW, GOI

***Co-Chairman* : Dr. Y.R. Meena**, Dy. Commissioner (Ext.), MOA&FW, GOI
Dr. Rajesh Malik, Director (Plant Protection), MOA&FW, GOI

***Convener* : Dr. (Ms.) Sabina Islam**, Sr.Scientist, ICAR-IARI, Pusa, New Delhi
Sh. Sanjay Singh, AD (Hort.), NHRDF, New Delhi

Theme of Presentation	Speaker
(a) Formation of FPOs and role for enhance income of farmers in horticulture sector	Mr. Vikash Bhat, AGM, NABARD, New Delhi
(b) Govt. scheme for enhance quality production in horticulture sector in the country	Dr. B.N.S. Murthy, Horticulture Commissioner, MOAF&W, GOI, New Delhi
(c) Extension is an instrumental tool for transfer of technologies to end users	Dr. Y.R. Meena, Dy. Commissioner (Ext.), MOAF&W, GOI, New Delhi
(d) Organic farming-A safe techniques of healthy horticulture food	Dr. Krishna Chandra, Director, NCOF, Ghaziabad

Technical Session-V: Peri-Urban Horticulture: Opportunities & Challenges

Date*:** 12th March, 2019 (Tuesday) ***Time: 12.30-14.30 hrs

***Chairman* : Dr. T. Janakiram**, Asstt. Director General (HS), ICAR, New Delhi

Co-Chairman : Dr. S.K. Singh, Head, Division of Horticulture, ICAR-IARI, Pusa, New Delhi
Dr. M.C. Singh, P.S., Division of Floriculture, ICAR-IARI, Pusa, New Delhi

***Convener* : Dr. R.K. Yadav**, Principal Scientist, ICAR-IARI, Pusa, New Delhi
Dr. D.K. Rana, SMS (PP), KVK, Ujwa, Delhi

Theme of Presentation	Speaker
(a) Quality sapling production of Horticulture Crops in peri-urban horticulture	Dr. S.K. Singh, Head, Division of Horticulture, ICAR-IARI, Pusa, New Delhi
(b) Landscaping & Floriculture an overview for employment and income generation	Dr. M.C. Singh, P.S, Div. of Floriculture & Landscaping, ICAR-IARI, Pusa, New Delhi
(c) Market linkage of Horticulture produces from field to fork	Mr. Mihir Mohanta, DGM, Mother Dairy, New Delhi
(d) Potential of speciality Melon-New opportunity of Protected cultivation	Dr. Harshwardhan, P.S., Div. of Veg. Science, ICAR-IARI, New Delhi
(e) Potential of Allium species of leafy vegetable	Dr. (Ms.) Sabina Islam, Sr. Scientist, ICAR-IARI, New Delhi
(f) Development of YVMV resistant variety and its production technology	Dr. R.K. Yadav, P.S, Div. of Veg. Science, ICAR-IARI, New Delhi

(g) Agriculture Entrepreneurs Pathway to Multi-opportunity for enhancing Quality Seed Production and Income	Dr. B.L. Saraswat, Executive Director, National Bee Board, MOA&FW, Govt. of India, New Delhi

Plenary Session

Date: 12th March, 2019 (Tuesday) 15.00-15.30 hrs

Chairman : **Dr. K.L. Chadha**, President, Horticulture Society of India, New Delhi

Co-Chairman : **Dr. P.K. Gupta**, Director, NHRDF, New Delhi
Dr. B.S. Tomar, Head, Division of Veg. Science, ICAR-IARI, New Delhi

Convener : **Shri B.K. Dubey**, Dy. Director (Breeding), NHRDF, Karnal
Shri H.K. Sharma, Dy. Director (Seed), NHRDF, New Delhi

Presentation of recommendations:	Name of Convener
Technical Session-I: Innovative Production Technologies of Onion & Garlic	Dr. Harshwardhan Choudhary, P.S, Div. of Veg. Science, IARI, New Delhi Dr. S.K. Tiwari, NHRDF, New Delhi
Technical Session-II: New Production Technologies of Potato	Sh. H.K. Sharma, Dy. Director (Seed), NHRDF, Delhi Dr. Vishwanathan, Scientist, ICAR-DOGR, Pune
Technical Session-III: Strategic Management of Post-Harvest Technologies of Onion, Garlic & Potato and their Export Potential	Dr. Ram Ashray, Principal Scientist, Division of Post-Harvest Technology, ICAR-IARI, Pusa, New Delhi Dr. Anil Khar, P.S, Division of Vegetable Science, IARI, Pusa, New Delhi
Technical Session-IV: Role of Govt. Scheme in uplifting the Livelihood of Farmers through Horticulture Crops	Ms. Sabina Islam, Sr. Scientist, ICAR-IARI, New Delhi Sh. Sanjay Singh, AD(Hort.), NHRDF, Delhi
Technical Session-V: Peri-Urban Horticulture: Opportunities & Challenges	Dr. R.K. Yadav, Principal Scientist, ICAR-IARI, New Delhi Dr. D.K. Rana, SMS (PP), KVK, Ujwa, Delhi

Closing Ceremony

Date: 12th March, 2019 (Tuesday) 15.30-16.00 hrs

Chief Guest **: Shri Ashok Dalwai**, IAS, Chairman, Committee for Doubling Farmers Income & Chief Executive Officer, National Rainfed Area Authority (NRAA), MOA&FW, Govt. of India, New Delhi

Vote of thanks **: Dr. P.K. Gupta**, Director, NHRDF, New Delhi

Achievement of NHRDF in Research and Development of Onion and Garlic in the Country

P.K. Gupta and S.K. Tiwari

National Horticultural Research and Development Foundation,
Janakpuri, New Delhi-110 058; E-mail: delhi@nhrdf.com; drpkgupta11@gmail.com.

The National Horticultural Research and Development Foundation (NHRDF) formerly known as Associated Agricultural Development Foundation (AADF) was established by National Agricultural Cooperative Marketing Federation of India Limited (NAFED) and Associate Shippers on 3rd November, 1977 under the 'Societies Registration Act, 1860 XXI' at Delhi to carry out research and other scientific studies on various export oriented horticultural crops particularly onion. Later on garlic was also included in its mandate in order to make available sufficient quantity for domestic consumption and also boost up the export of onion and garlic in the country. In recent years, the NHRDF has extended its R&D programmes on some other export oriented horticultural crops like potato, pea, cowpea, tomato, okra, french bean, chilli, and bitter gourd in view of the vast export potential.

Recognizing the services of NHRDF, Ministry of Agriculture and Farmers Welfare, Govt. of India has given additional responsibility as an implementing agency of the 'Central Sector Scheme on Garlic and Spice Development', and Integrated Development of Vegetables including Root and Tuber crops' during tenth five-year plan. During the eleventh five-year plan, the NHRDF has been identified as a National Level Agency at central level for execution of different developmental and seed production programmes of 'National Horticulture Mission' now MIDH and the 'National Vegetable Initiatives for Urban Clusters' (NVIUC). The NHRDF is also a voluntary Centre for conducting network Research Programmes under the All India Coordinated Research Programme (Vegetable crops)[AICRP-VC] and All India Network Research Project on Onion and Garlic[AINRPOG] and Monitoring of Pesticides Residue at National Level [MPRNL]. The NHRDF implemented various other projects funded by the Ministry of Agriculture & Farmers Welfare, Govt. of India, NAFED, NHB, UNDP, ICAR and State Govt on different vegetables particularly on onion and garlic under its research and developmental programmes.

The management of NHRDF vests in the Managing Committee, which consists of 4 representatives from NAFED wherein Managing Director is ex officiao,5 from Associate shippers ,6 from progressive farmers engaged in cultivation of horticultural crops, 4 from eminent scientist /expert in respective field and Director NHRDF is Member Secretory of the committee.

Infrastructures

The NHRDF has created infrastructural facilities to carry out Research and Developmental activities in the field and laboratory on all aspects of different export-oriented horticultural crops. The NHRDF established research stations and extension centres in different states of the country. It has 5 Regional Research Stations (RRSs) and 13 Extension Centres (ECs) in different agro climatic zone of the country. It has also established one Krishi Vigyan Kendra at Ujwa in New Delhi fully funded by ICAR to cater to the needs of the farmers of Delhi state.

The NHRDF has well-developed research farm along with requisite buildings etc. at its Regional Research Stations, viz. 18 acres land at Karnal (Haryana), 42.50 acres at Kundewadi, Sinnar, Nashik and 18.50 acres in Chitegaon Phata, Nashik (Maharashtra), 10 acres at Kombai, Dindigul (Tamil Nadu), 40 acres at Ujwa, New Delhi and 50 acre at Paljhar, Boudh (Odisha). The seed processing plants are established at Lasalgaon (Maharashtra), Rajkot (Gujarat), Karnal (Haryana), Indore (M.P), Deoria (U.P) and Kurnool (A.P). Dehumidified seed stores are also established at Lasalgaon and Chitegaon Phata in Nashik district of Maharashtra; Janakpuri in New Delhi; Rajkot in Gujarat; Karnal in Haryana and Indore in Madhya Pradesh, Deoria in U.P, Kurnool in A.P. & Boudh in Odisha. One Model Post-Harvest Research Complex (PHRC) in 10 acre land at Lasalgaon, Nashik (Maharashtra) having 10 handling sheds of 100 MT capacity each, 20 Modern Onion Storage Godowns of 50 MT capacity each have been also established by NHRDF for providing training and providing infrastructural support to onion growers, traders and exporter on Post Harvest Management of Onion.

Laboratories

The NHRDF has also established laboratories at its Regional Research Stations Karnal and Chitegaon Phata, Nashik. The laboratories on Seed Testing. Plant Pathology, Entomology, Plant Physiology, Bio-chemistry and Soil Testing have been established at Nashik and Karnal. The Seed Testing, Mushroom Spawns and Pasteurized Compost Production Unit have been established at Janakpuri and Ujwa in New Delhi. Besides, NHRDF has established one of the most sophisticated and modern Pesticide Residue Analysis Laboratory (PRAL) under quality control lab scheme and same recognized by APEDA,

Ministry of Commerce, Govt. of India, New Delhi as well as wine testing laboratory has also been recognized by European Union for pesticide residue testing in all agricultural and horticultural produce, processed food and wine which is being exported from India. The laboratory has also been accredited by the National Accreditation Board for Testing & Calibration Laboratories (NABL). The PRA lab is also recognized from Directorate of Marketing and Inspection, Ministry of Agriculture & Farmers Welfare, Government of India for issue Agmark certificate of agriculture produce for export purpose. A geo-informatics laboratory is also established at Nashik for area estimation through satellite image on onion, tomato, chili etc.

The Bio-control Laboratories for production of bio-pesticides at Nashik and Karnal have also been established for production of high quality bio-products namely Tricho-vir (*Trichoderma virdi*), Bio-Brave (*Beuveria bassiana*), Pseudo-Guard (*Psuedamonas fluorascens) and* S-Guard (*Spodopetra Nuclear Polyhydrosis Virus*).

Information Centre

The NHRDF has established information centre one each at Nashik and New Delhi to gather and disseminate the information on area, production, crop condition, marketing, availability and export of horticultural crops particularly on onion, garlic ,potato and tomato. The information on area, production, export and market data of onion, potato and garlic are being uploaded on daily basis on website www.nhrdf.org for the benefit of the farmers, exporters and others concerned. The data available on this website since 1980.

I. RESEARCH

The NHRDF has a Scientific Advisory Committee for review of the research and developmental activities and finalizing the future technical programme and developmental activities. The committee is headed by Deputy Director General (Horticultural Science), Indian Council of Agricultural Research (ICAR), Depts of Agriculture Research & Education (DARE), Ministry of Agriculture & Farmers Welfare, Govt. of India and 10 eminent scientists from ICAR institutes, SAUs from different disciplines and the Director, NHRDF as Member Secretary of the committee. The committee meets twice in a year to discuss research and developmental activities.

During 41 years of span, NHRDF has developed 14 and 17 lines / varieties of onion and garlic respectively for different agro climatic zone and seasons. Out of these, 6 varieties of onion and 10 varieties of garlic was notified by Sub Varieties Release Committee. Seed Division, Dept. of Agriculture & Co-op., Ministry of Agriculture & Farmers Welfare, Govt. of India time to time.

Around 250 technologies developed for Maharashtra and Haryana in different segment for onion and garlic. The variety-wise specification of both crops is given below:

A-Onion varieties/Lines

i) **Agrifound Dark Red:** Bulbs are dark red, globular round in shape 4-6 cm in size with tight skin and moderately pungent. Bulbs mature 90-100 days after transplanting. Total soluble solid (12-12%), dry matter (13-14%) and pyruvic acid 10.07 micro mole/g. Average yield is 300 q/ha. Notified by Govt. of India for growing in *kharif* season in the country vide notification number 1135(E) dated 01/12/1998.

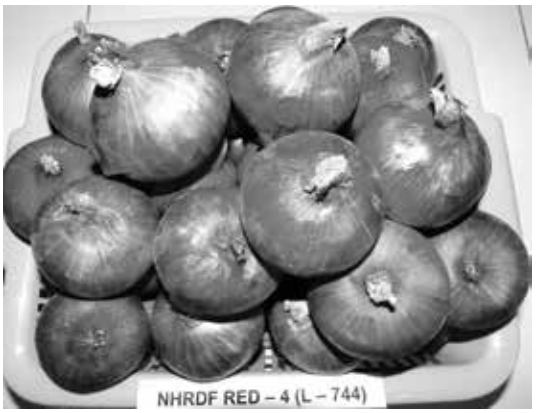
ii) **Agrifound Light Red:** Bulbs are attractive dark, globular round in shape, reddish thick inner scales. Bulb matures 110-120 days after transplanting. Keeping quality is good. Total soluble solid (13%), dry matter (14-15%) and pyruvic acid 12.20 micro mole/g. Average yield is 300-350 q/ha. Notified by Govt. of India for growing in *rabi* season in the country vide notification number 1135(E) dated 10/02/1996.

iii) **NHRDF Red(L-28):** Bulb are attractive dark red, globular round in shape, reddish thick inner scales. Bulb matures 110-120 days after transplanting. Keeping quality is medium. Total soluble solid (13-14%), dry matter (14-15%) and pyruvic acid 12.0 micro mole/g. Average yield is 250-300 q/ha. Notified by Govt. of India for cultivation in Northern, Central and Western India in *rabi* season vide notification number SO-2035(E) dated 28/10/2001.

iv) **NHRDF Red-2 (L-355):** Bulb are attractive light red in colour, globular round in shape, thin neck and 5.0-6.0 cm in diameter. Bulb matures in 100-120 days after transplanting. Keeping quality good. Total soluble solid (13-14%), dry matter (14-15%) and pyruvic acid 12.0 micro mole/g. Average yield is 350-375 q/ha. Notified by Govt. of India for *rabi* season in zone III (Delhi, Uttar Pradesh, Haryana and Gujarat) and Zone VI (Maharashtra, Karnataka and Andhra Pradesh) vide notification number SO-2363(E) dated 01/10/2012.

v) **NHRDF Red-3:** Bulbs are light bronze in colour, globular round shape, thin neck and 5.5-6.0 cm in diameter. Bulb matures in 120-130 days after transplanting. Keeping quality is good. Total soluble solid (12-13%), dry matter (13-14%) and pyruvic acid 12.50 micro mole/g. Average yield is 350-400 q/ha. Recommended for *rabi* season in Maharashtra, Madhya Pradesh, Gujarat, Delhi, Uttar Pradesh, Bihar, Punjab, Haryana and Rajasthan.

vi) **NHRDF Red-4:** Bulbs are dark red in colour globular round shape, thin neck and 5.5-6.25 cm in diameter. Bulb matures in 110-120 days after transplanting. Keeping quality is good. Total soluble solid (12-14%), dry matter (13-14%) and pyruvic acid 13.0 micro mole/g. Average yield is 350-400 q/ha. Notified by Govt. of India for rabi season in zone III (Uttar Pradesh, Bihar, West Bengal and Imphal) vide notification number SO-3666(E) dated 06/12/2016.



vii) **Agrifound White:** Bulbs are white, globular in shape with tight skin and silvery attractive. Bulb matures 110-120 days after transplanting. Keeping quality is Medium

to good. Total soluble solid (14-15%), dry matter (15-16%) and pyruvic acid 12.0 micro mole/g. Suitable for dehydration. Average yield is 250-300 q/ha. Recommended for *late kharif* and *rabi* season for Maharashtra, Madhya Pradesh, Gujarat and Rajasthan.

viii) **NHRDF Fursungi (L-719) :** Plants are erect, strong, red coloured bulb, round shaped 5.80 to 6.25 cm in diameter, bulb matures in 110-120 days after transplanting. Total soluble solid (12-14%), dry matter (13-15%). Average yield is 380-400 q/ha with good keeping quality. Tolerance for Stemphylium Blight. Variety is recommended for cultivation in Zone-II (Delhi, Rajasthan, Haryana, Jammu & Kashmir & Punjab), Zone – V (Gujarat & Maharashtra) during the 8th Group Meeting of AINRPOG organized at Rajasthan Agriculture Research Station, Durgapura, Jaipur on 1-2, July, 2017and same is under notification process.

ix) **Agrifound Rose:** Bulbs are deep scarlet red, flattish round in shape, 2.5-3.5 cm in size and pickling type. Matures in 95-110 days after sowing. Total soluble solid (16-18%), dry matter (17-19%) and pyruvic acid 10.27 micro mole/g suitable for dehydration. Average yield is 250-300 q/ha. Recommended for growing in *kharif* season in Cuddapah (AP) and in all the three seasons in Karnataka.

x) **Agrifound Red:** Bulblets light red, size of bulblets is 3.64 cm, number of bulblets per cluster 5-6 and weight of single bulblets is 8.85 g. Average weight of cluster is 65-67 g. Bulblets matures 65-67 days after planting. Total soluble solid (17-19%), dry matter (18-20%)

and pyruvic acid 10.13 micro mole/g. Average yield is 180-200 q/ha. Recommended for *kharif* and *rabi* season in zone VIII (Karnataka, Tamil Nadu and Kerala).

xi) **Advance Line – 863:** Bulbs are dark red coloured, round shape, diameter 4-5-5 cm & keeping quality medium. Crop matures in 80-85 days after transplanting, Total soluble solid (12-13%), dry matter (11-12%) pyruvic acid (12.5-13 micro mole/g). Average yield is 280-300 q/ha. Variety is recommended for cultivation in *kharif* and Late *kharif* season.

xii) **Advance Line – 883 :** Bulbs are dark red colour, round shape, shiny skin, 4.50 – 5.50 cm diameter. Bulb are matures in 85-90 days after transplanting. Total soluble solid (12-13%), dry matter (13-14%) pyruvic acid (12.0 micro mole/g). Average yield is 300-325 q/ha. Variety is recommended for cultivation in kharif and Early kharif season all over India.

xiii) **Advance Line-857:** The bulb of this line is round globular and silvery white colour, mature in 110-120 day after transplanting, Average yield is 350-400 q/ha, TSS 14-15 %and good storage capacity. Suitable for cultivation in *rabi* season in central India .This line under evaluation in network trial.

xiv) **Advance line 849:** The bulb of this line is globular round shaped with attractive red colour, mature in 105-115 day after transplanting. High yield potential is 375-425 q/ha. Suitable to grow in *rabi* season in central part of the India. Good storage capacity about 6 month and moderately tolerant to

stemphyllium blight & purple blotch disease.

B. Garlic Varieties/Lines

i) **Agrifound White (G-41):** Bulbs are compact, silvery and white with creamy flesh, bigger elongated clove with 20-25 in number and diameter of bulb is 3.5 to 4.5 cm, total soluble solids (41%), dry matter (43%) and pyruvic acid is 27 micro mole/g. Matures in 140-150 days, average yield 130 q/ha. Notified by Govt. of India for Maharashtra and Madhya Pradesh vide notification number 280(E) dated 13/04/1989.

ii) **Yamuna Safed (G-1):** Bulb are compact, silvery white skin with creamy flesh, diameter 4.0-4.5 cm. Sickle shaped cloves with 25-30 in number, total soluble solids (38%), dry matter (40%) and pyruvic acid (29 micro mole/g). matures in 140-150 days, average yield 150-175 q/ha. Notified by Govt. of India for cultivation in all over the country vide notification number 527(E) dated 16/08/1991.

iii) **Yamuna Safed-2 (G-50):** Bulbs are compact, attractive, while creamy flesh and average diameter is 3.5-4.0 cm. Number of cloves 35-40, total soluble solids (39%), dry matter (41.0%) and pyruvic acid (26 micro mole/g), matures in 140-160 days, average yield 150-200 q/ha. Notified by Govt. of India for cultivation in Northern India vide notification number 115(E) dated 10/02/1996.

iv) **Yamuna Safed-3 (G-282):** Bulbs are

creamy white and bigger sized with 4.5-5.5 cm in diameter, number of cloves/bulb is 15-16, total soluble solids (40%), dry matter (42.0%) and pyruvic acid (25 micro mole/g), matures in 120-140 days, average yield 175-200 q/ha. Notified by Govt. of India for Madhya Pradesh, Maharashtra, Haryana, Gujarat, Punjab, Rajasthan, Uttar Pradesh and Chhattisgarh vide notification number 1052(E) dated 26/10/1999.

v) **Yamuna Safed-4 (G-323):** Bulbs are silvery white and average diameter is 3.5-4.0 cm, number of cloves 20-25/ bulb, total soluble solids (42%), dry matter (44.5%) and pyruvic acid (25 micro mole/g), matures in 140-150 days, average yield 175-200 q/ha. Notified by Govt. of India for North and Central India vide notification number 597(E) dated 25/04/2006.

vii) **Yamuna Safed-5 (G-189):** Bulbs are creamy white and bigger sized with 4.5-5 cm in diameter, number of cloves/ bulb is 22-30, suitable for processing purpose, total soluble solids (42%), dry matter (44%) and pyruvic acid (26 micro mole/g), matures in 140-160 days, average yield 150-180 q/ha. Notified by Govt. of India for Zone III (Delhi, Uttar Pradesh, Haryana, Bihar and Punjab) Zone-IV (Rajasthan and Gujarat) and Zone VI (Maharashtra, Karnataka and Andhra Pradesh) vide notification number 2363(E) dated 10/04/2012.

vii) **Yamuna Safed-8 (G-384):** Dark green plant, straight erects leaves, average bulb diameter 4.30 to 5.00 cm, total soluble solids (40%), dry matter (42%) and pyruvic acid (26 micro mole/g), matures in 150-160 days, average yield 175-200 q/ha. Notified by Govt. of India for Zone II (Jammu, Ludhiana, Delhi, Karnal, Hissar and Durgapura)

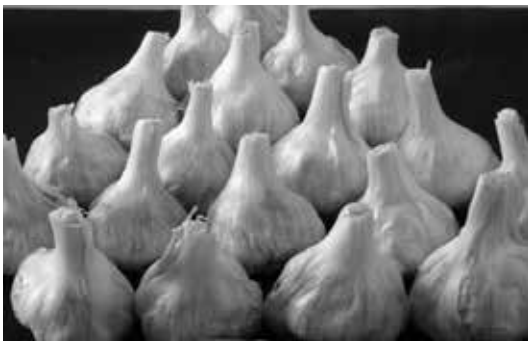
vide notification number 268(E) dated 28/01/2015.

viii) **Yamuna Safed-9 (G-386):** Dark green plant, plant straight, erect leaves; average bulb diameter 4.80 to 5.50 cm, average numbers of clove per 22-30 and clove diameter is 1.30-1.50 cm, total soluble solids (40%), dry matter(43%) and pyruvic acid (25 micro mole/g), mature in 150-160 days, average yield potential is 180-225 q/ha. Notified by GOI for Zone II (Jammu & Kashmir, Punjab, Delhi, Haryana and Rajasthan) vide notification number 3666(E) dated 12/06/2016.

ix) **Agrifound Parvati (G-313):** Bulbs are bigger size 5.0 – 6.5 cm in diameter, creamy white colour with pinkish tinge, 10-16 cloves/bulb, total soluble solids (36%), dry matter (38.5%) and pyruvic acid (23 micro mole/g), mature in 230-250 days, average yield 200-225 q/ha. Notified by Govt. of India for Zone-I (Jammu Kashmir and Himachal Pradesh) vide notification number 268(E) dated 28/01/2015.

x) **Agrifound Parvati-2 (G-408):** Bulbs are bigger size 5.0-6.0 cm in diameter, creamy white colour, 12-14 cloves/ bulb, total soluble solids (37%), dry matter (39.0%) and pyruvic acid (23 micro mole/g), mature in 240-260 days, average yield 200-225 q/ha. Notified by Govt. of India for Zone I (Jammu Kashmir and Himachal Pradesh) vide notification number 268(E) dated 28/01/2015.

xi) **Advance line G-389:** This is first variety which is cultivated in *kharif* season. Bulb diameter 3.0-3.50 cm. 20-25 cloves/bulb, total soluble solids (34-36%), dry matter (35-38.0%), mature in 75-80 days in *kharif* & 85-90 days in *rabi* season. Average yield during *kharif* is 40-60 q/ha & during *rabi* 60-70 q/ha. This line under AINRPOG evaluation.



xii) **Advance line G-404:** Plants are straight with broad dark green leaves. The bulbs are compact, attractive light purple colour, average bulb diameter 4.80 to 5.50 cm, average number of clove per bulb 25-30 with creamy flesh, bigger elongated cloves and clove diameter 1.00 cm to 1.18 cm, total soluble solids 39-40 %, Dry matter 42% and pyruvic acid 26.80 micromole/g, average weight of 50 cloves 80-100 g, mature in 160-170 days, average marketable yield 165-175 q/ha. This line under AINRPOG evaluation.

xiii) **Advance line G-324:** Plants are long straight with green leaves. Bulbs are compact, white colour, average bulb diameter 4.50 to 4.80 cm, average number of clove per bulb 27-30 with creamy flesh and clove diameter 0.8 cm to 1.0 cm, total soluble solids 39-40 %, Dry matter 42 % and pyruvic acid 25.5 Micromole/g, average weight of 50 cloves 45-50 gm, crop mature in 155-165 days, average marketable yield 145-150 q/ha. Storage keeping quality is good. This line under AINRPOG evaluation.

xiv) **Advance line G-378:** Plants are straight with dark green leaves. Bulbs are compact, bold white colour, average bulb diameter 4.50 to 4.80 cm, average number of clove per bulb 20-25 with creamy flesh, bigger bold cloves and clove diameter 1.0 cm to 1.2 cm, total soluble solids 38-39 %, Dry matter 41.0

% and pyruvic acid 25.0 micromole/g, average weight of 50 cloves is 80-85 gm, Early variety mature in 145-150 days, average marketable yield 155-165 q/ha. This line under AINRPOG evaluation .

xv) **Advance line G-417:** Plants are straight with broad dark green leaves. Bulbs are compact, attractive creamy white colour, average bulb diameter 4.50 to 5.00 cm, average number of clove per bulb 26-35 with creamy flesh, bigger elongated cloves and clove diameter 0.9 cm to 1.2 cm, total soluble solids 39-40 %, Dry matter 42.0 % and pyruvic acid 26. 0 micromole/g, average weight of 50 cloves is 85-90 gm, mature in 150-160 days, average marketable yield 160-165 q/ha. This line under AINRPOG evaluation.

xvi) **Advance line G-363:** Plants are straight with moderate green leaves. Bulbs are compact, attractive white colour, average bulb diameter 4.50 to 5.20 cm, average number of cloves per bulb 27-30 with creamy flesh, bold cloves, total soluble solids 39-40 %, Dry matter 42.0% and pyruvic acid 26.0 micromole/g, average weight of 50 cloves is 70-78 g, mature in 150-160 days, average marketable yield 150-165 q/ha. his line under AINRPOG evaluation.

xvii) **Advance line G-304:** Plants are straight with broad dark green leaves. Bulbs are bold compact, attractive white colour, average bulb diameter 4.50 to 5.00 cm, average number of clove per bulb 24-30 with creamy flesh, bigger bold cloves and clove diameter 0.9 cm to 1.2 cm, total soluble solids 38-39 %, Dry matter 41.0 % and pyruvic acid 25.0 micromole/g, average weight of 50 cloves 75-78 gm, mature in 150-160 day, average marketable yield 160-170 q/ha. his line under AINRPOG evaluation .

C. Technologies Recommended

Apart from above varieties developed by NHRDF, different technologies also developed on onion and garlic for the *kharif*, late *kharif* & *rabi* seasons for Maharashtra & Haryana reason. The other technologies are discussed during the each scientific advisory committee meeting and same recommended to farming community of Maharashtra and Haryana. As per the segment and specialized field the technologies in number are given below:

Onion

A. Crop Production System Management

a)	Nursery Management	-15
b)	Bulb Production	-21
c)	Nutrient Management	-42
d)	Weed Management	-13
e)	Irrigation Management	-5

B. Plant Health Management

a)	Disease Management	-29
b)	Insect Pest Management	-32
c)	Post Harvest Management	-33

C. Seed Technology

a)	Seed Production Management	-15
b)	Plant Health Management	-08
c)	Post Harvest Technology	-06

Garlic

A. Crop Production System Management

a)	Bulb Production	-15
b)	Nutrient, Irrigation and Weed Management	-14

B. Plant Health Management

a)	Disease Management	-12
b)	Insect Pest Management	-08
c)	Post-Harvest Management	-22

Popular rainy (*kharif*) season onion production

Rainy season onion production which was not common in northern parts of the country. NHRDF has demonstrated and popularized onion production during rainy season in Northern states by providing seeds and technology to the farmers, which is major achievement for increasing onion productivity in the country.

Onion production through bulblets

The onion bulblet technologies first time introduced by NHRDF during 2005 in the country after rigours research work and adopted in northern part India *i.e* Alwar district in Rajshthan, Mewat district in Haryana and Western part of India Mahua taluka in Bhawanagar district of Gujrat.

Kharif onion since cultivated during monsoon season, it has been observed that nursery is damaged during heavy rainfall or due to unfavourable climatic conditions. The technology of production of *kharif* onion through sets (bulblets) has already been standardized by NHRDF. The NHRDF distributing seeds of *kharif* onion varieties Agrifound Dark Red for production of sets in states of Gujarat, Rajasthan, Haryana and

Fig. 1: *Onion bulblets with dry leaves ready for storage*

Punjab and onion growers engaged in bulblets production. The production of *kharif* onion using bulblets now became popular in these states, which helping in making available fresh crop during lean period of less availability of onion and demand in more i.e. September/October.

Fig. 2: *Onion bulblets under storage in crates*

Improved ventilated onion storage godown

NHRDF has developed ventilated onion storage godowns and popularized amongst farmers for storing onions and also established curing and storage facilities for training purpose for farmer's traders and exporters at PHRC Lasalgoan. This storage is very popular in onion growing storage and Ministry of Agriculture & Farmers Welfare, Govt. of India providing assistance to onion growers in different scheme through state govt. Due to this onion storage capacity is increasing trends.

Fig. 3: *50 MT capacity Low Cost Onion Storages*

II. DEVELOPMENTAL ACTIVITIES

By the above achievements by the NHRDF in the area of onion and garlic in last 41 years the area, production and productivity as well as onion export under these bulbous crop increase many folds. NHRDF has developed improved Production and Post-Harvest Technologies of onion and garlic with seed production, processing and packing technologies, which are being passed on to the growers in the country through its Extension Centres by arranging demonstrations, seminars, meetings, group visits etc. under the Central Sector Schemes of the Govt. of India and the farmers are adopting the same for taking commercial production of onion and garlic bulbs as well as seed production.

NHRDF provides training to government officials, extension Functionaries, Elite Farmer, Student and other Stake holder, on "Production and Post-Harvest Technology on Onion, Garlic, Potato and other export-oriented vegetable crops as well as Mushroom Production Technology and Market Linkage at its head office Janakpuri, New Delhi and Regional Research Station Nashik and Karnal. The Govt official of Agriculture and Horticulture Deptt, Progressive Farmers and entrepreneurs of SAARC countries like Nepal, Bangaldesh, Bhutan, Nepal and Sri Lanka also participated various training programmes organized by us.

Onion and garlic are two important vegetable crops grown in India since long and are consumed by common masses round the year in our country. Besides being rich in their nutritional status and medicinal values, these crops have an excellent export potential. It is used as salad and cooked in various ways in carries, fried, boiled, baked, used in soup making and pickles. The medicinal properties of onion and garlic as anti-microbial and antibiotic are well recognized. Though common onion is not rich in food value, these have got considerable quantity of cellulose and sugar. Common onion ranks medium in the supply proteins, calorie value and vitamin B & C. Small onions are, however more nutritive than big onions. The onion is regarded as highly export oriented crop amongst vegetables and earning valuable foreign exchange for India.

Seed Production and Distribution

Starting from 3 kg of onion seed in 1979, the NHRDF is now producing over 500 tonnes of onion seed of different notified varieties annually and distribute to farmers at their doorsteps. In garlic, the NHRDF produces more than 2000 tonnes of garlic seed bulb annually. The replacement of onion and garlic varieties are achieved to a considerable extent through distribution of quality seed of onion and planting material of garlic. The seed and planting materials are distributed through various centres

of NHRDF in different parts of the country. Popularization of improved varieties of onion and garlic, production and distribution of quality seed all over the country have been well in India. The increase in area, production, productivity, exports and per capita availability due to work done by NHRDF during last 41 years are given in below table:

Crop Particular	Onion			Garlic		
	1978-79	2016-17	Increase (%)	1978-79	2016-17	Increase (%)
Area (000 ha)	246.10	1270.00	416.05	49.40	274.00	454.66
Production (000 t)	2565.70	29564.00	740.47	167.40	1279.00	659.29
Productivity (t/ha)	10.43	96.98	62.87	3.39	4.64	36.89
Export (lakh MT)	0.96	34.93	3556.02	0.04	0.96	288.00
Availability (kg/year/person)	3.88	16.46	324.14	0.24	0.97	304.26

National Scenario of Onion and Garlic

Onion is the most widely cultivated and important vegetable or spices and queen of the kitchen. It belongs to the family of *Liliaceae*. Onion is a known traditional nutraceutical and medicinal plant. Onion contain phenolics and flavonoids, which have potential anti-inflammatory, anti-cholesterol, anticancer and antioxidant properties. Onions contains 89% water, 1.5 % protein, and vitamins B_1, B_2 and C along with potassium and selenium. In world's greatest onion producing countries, China and India are the leading countries. As the second largest onion growing country in the world, India accounts (215.64 lakh millions tons) for about 16% of world production, occupies first rank in total area (12.70 lakh hectare), while the productivity is very low (16.97 ton ha^{-1}) as compared to international productivity (17.27 ton ha^{-1}). Reasons for lower production and productivity are lack of high yielding varieties, use of low yielding varieties, non-availability of quality seed in adequate quantity, imbalanced nutrition with low or no inputs and poor management practices like water and plant protection activities. As on date Maharashtra and Karnataka are the two states that contributes huge share in the production of onions In India. Maharashtra ranks first in area under onion factor having around 30% share. It also ranks first in terms of production of onion contributing around 33% share. In terms of state-wise yield of onion, Karnataka has highest yield (14.40 tons/ha) followed by Maharashtra having yield of 14.20 tons/ha.

The trend is shown through tables and graphs as given below:

Table No. 1 : Area, Production & Productivity of Onion of last four decades

(Area in 000 ha and production in 000 MT)

Year	Area	Production	Productivity (q)
1980-1990	2707.00	27949.30	10.32
1990-2000	3794.50	40063.70	10.55
2000-2010	6021.45	78729.12	13.07
2010-2018	9520.53	153201.76	16.09

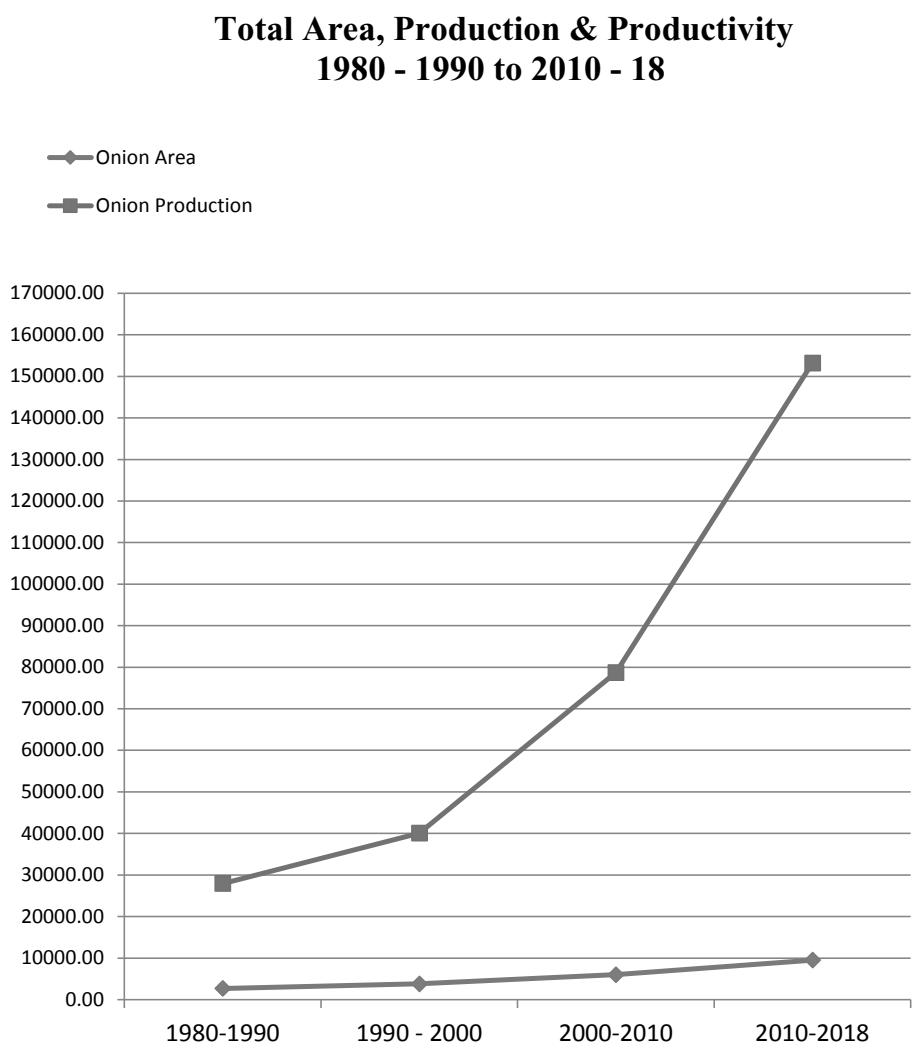


Fig. No. 4: *Area, production & productivity of onion in the country during last four decades.*

Table No. 2: Year wise Area, Production and Productivity of onion during 1979 to 2018

(Area in 000 ha and production in 000 MT)

Year	Area	Production	Productivity (q)
1979-1980	249.30	2500.50	10.03
1980-1981	250.60	2610.00	10.42
1981-1982	250.90	2597.80	10.35
1982-1983	234.90	2396.50	10.20
1983-1984	270.40	2699.10	9.98
1984-1985	278.20	3098.80	11.14
1985-1986	279.60	2862.50	10.24
1986-1987	266.90	2719.40	10.19
1987-1988	259.10	2553.40	9.85
1988-1989	315.20	3347.20	10.62
1989-1990	301.20	3064.60	10.17
1990-1991	296.90	3148.30	10.60
1991-1992	308.40	3343.80	10.84
1992-1993	321.50	3589.90	11.17
1993-1994	367.50	4006.20	10.90
1994-1995	378.60	4035.90	10.66
1995-1996	395.50	4079.60	10.32
1996-1997	409.70	4428.20	10.81
1997-1998	355.00	3200.60	9.02
1998-1999	468.10	5331.90	11.39
1999-2000	493.30	4899.30	9.93
2000-2001	421.90	4550.50	10.79
2001-2002	452.10	4831.00	10.69
2002-2003	435.40	4506.10	10.35
2003-2004	502.60	5922.50	11.78
2004-2005	549.10	6434.60	11.72
2005-2006	661.90	8682.60	13.12

Year	Area	Production	Productivity (q)
2006-2007	702.10	8885.14	12.66
2007-2008	704.35	9137.98	12.97
2008-2009	835.20	13588.00	16.27
2009-2010	756.80	12190.70	16.11
2010-2011	1064.00	15117.90	14.21
2011-2012	1087.26	17511.10	16.11
2012-2013	1051.55	16813.00	15.99
2013-2014	1203.59	19401.69	16.12
2014-2015	1173.36	18928.39	16.13
2015-2016	1320.13	20931.25	15.86
2016-2017	1305.64	22427.43	17.18
2017-2018	1315.00	22071.00	16.78

Table No. 3: Garlic Area, Production & Productivity during 1990- 2018

Year	Area	Production	Productivity (q)
1990-1991	89.70	350.90	3.91
1991-1992	92.80	364.00	3.92
1992-1993	85.50	355.80	4.16
1993-1994	76.20	306.00	4.02
1994-1995	98.90	403.20	4.08
1995-1996	114.80	490.00	4.27
1996-1997	96.60	451.50	4.67
1997-1998	108.80	484.40	4.45
1998-1999	123.20	570.80	4.63
1999-2000	118.80	495.30	4.17
2000-2001	103.08	487.80	4.73
2001-2002	115.72	530.80	4.59
2002-2003	112.45	468.31	4.16

Year	Area	Production	Productivity (q)
2003-2004	138.90	691.10	4.98
2004-2005	144.10	646.60	4.49
2005-2006	134.90	597.90	4.43
2006-2007	159.20	776.26	4.88
2007-2008	205.08	1068.42	5.21
2008-2009	164.92	876.75	5.32
2009-2010	166.48	890.11	5.35
2010-2011	200.19	1057.84	5.28
2011-2012	245.16	1225.50	5.00
2012-2013	247.52	1259.27	5.09
2013-2014	230.59	1251.88	5.43
2014-2015	262.06	1425.46	5.44
2015-2016	280.95	1617.34	5.76
2016-2017	320.93	1693.20	5.28
2017-2018	303.00	1721.00	5.68

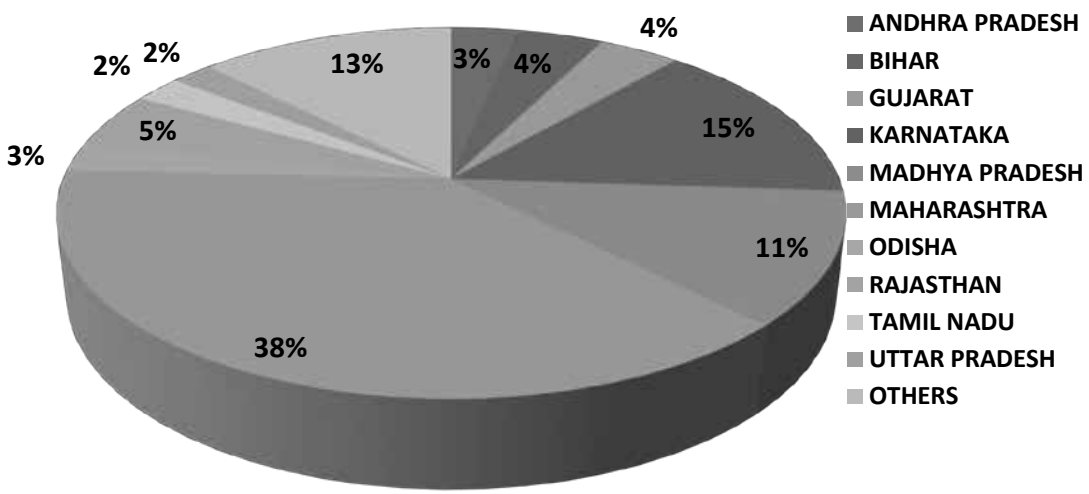


Fig. No. 5: *Distribution of area under onion in India during 2017-18*

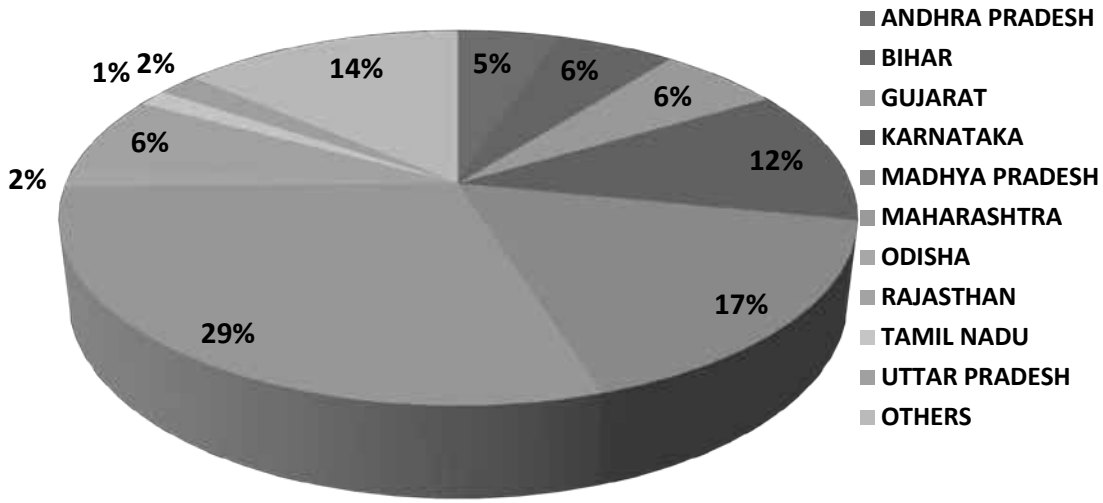


Fig. No. 6: *Production of onion in states during 2017-18*

Table No. 4 : Area, Production & Productivity of Garlic during last 3 decades

Year	Area	Production	Productivity (q)
1990-1999	1005.3	4271.9	4.25
2000-2009	1444.83	7034.05	4.86
2010-2017	2090.4	11251.49	5.38

Table No. 5: Onion Consumption Calculation

Region	Population	Per capita consumption in 30 Days (Kg)	Total Onion Capita in 30 Days (Kg)	Total Onion Capita in 30 Days (MT)	Total Onion Capita in 1 Year (MT)
Rural	833748852	0.842	702016533	702017	8541201
Urban	377106125	0.951	358624925	358628	4363306
Total Onion Capita in 1 Year in MT (Rural & Urban)					12904508

Reference:- 1. Population- Ministry of Home Affairs; 2. Per Capita Consumption- Household Consumption of Various Goods and Services In India 2011-12 (NSS 68th Round June 2014)
10.75 La. MT/month; Yearly- 144 Lac. MT

Export of Onion Mt/Rs.

Exports of onion are increasing year on year drastically. Though there have been various restrictions like MEP, exports still have increasing trend. This is reducing trade

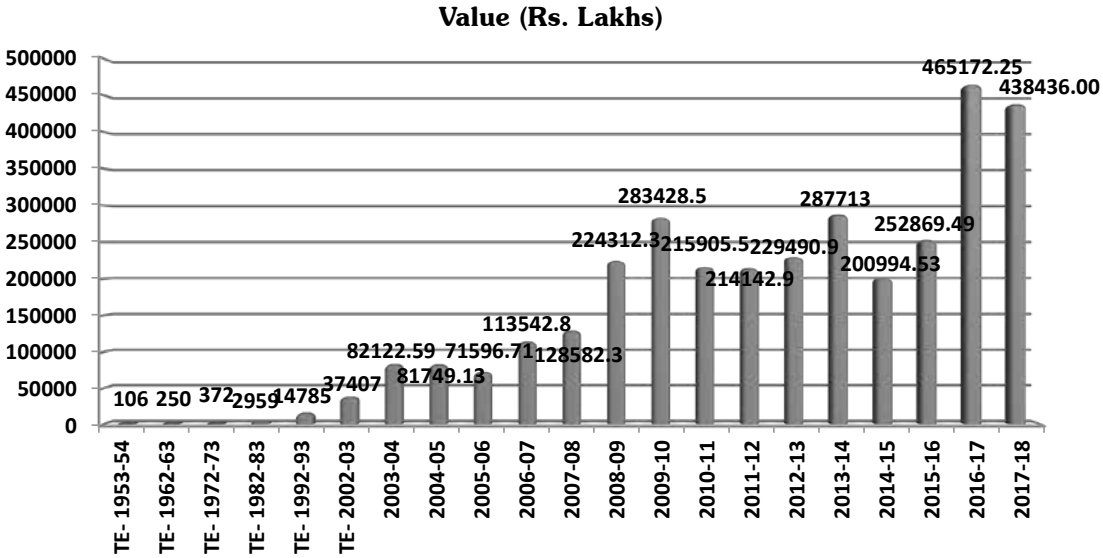


Fig. No. 7: *Onion export from India*

deficit of India, which is one of the most severe problems in India economy. We have lot of more potential of onion exports. The graphs is indicated that onion export from India.

Insect Pest Management in Onion and Garlic

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Onion and garlic are most important vegetable crops grown throughout India. Like any other vegetables, full yield potential of both crops is not realized due to a number of constraints. Among them, pests and diseases are major constraints in onion and garlic production. Onion and garlic are susceptible to various pests, viz. thrips, mites, armyworms, cutworms, leaf miner etc. Onion thrips being cosmopolitan appears wherever onions are cultivated and increases tremendously under hot and dry conditions. Even today, chemical control remains mainstay to manage this pest. Owing to widespread use of chemicals and high residue problems pose serious threat to human health and environment. Hence, integrated pest management has become imperative. Onion thrips (*Thrips tabaci*), is the key pest of onion and garlic, causing 35-45% yield loss. It also acts as vector for various plant virus diseases. Pest and disease may occur simultaneously, while pest may even aggravate the disease severity. Although thrips remains the major pest, some other pests with less importance also occur sporadically. In recent times, impact of climate change is more evident and visible with a shift of pest scenario, where in the rise in temperature may facilitate mite infestation. To ward off these pests, farmers solely rely on chemical pesticides. However, chemo-intensive practice alone cannot provide adequate protection. This warrants an integrated approach to minimize the yield loss and to obtain good quality marketable bulb. In India the farmers do not follow principles of crop rotation due to intensive cultivation and therefore the insect pests and diseases get favourable conditions for their establishment and dissemination resulting in heavy losses. The detailed description of the insect pests are as under:

(1) Onion thrips:

Scientific Name: *Thrips tabaci* (Lindeman)

Order: Thysanoptera

Family: Thripidae

Onion thrips (*Thrips tabaci*) is the well known pest of onion throughout the world. Almost all types of vegetables, including weeds are affected by this pest, but onion

and garlic are crops that are damaged most. Besides, it is cosmopolitan in nature, polyphagous, transmits plant pathogens, have high reproductive rate (more generations at high temperatures), asexual mode of reproduction (parthenogenesis), high survival via cryptic (non feeding prepupa) instars and develop insecticide resistance. Hence, thrips become a global pest with increasing concern in commercial onion.

Geographic Distribution & Host

In India, *T. tabaci* is the pest of national significance widely distributed in all onion-growing seasons. This pest is active throughout the year and breeds on onion and garlic from November to May. Later on, migrates to alternate summer host plants including weeds.

- World wide
- It is an important pest of onions, garlic and several other crops in most parts of the world
- Thrips can colonize crops from sea level up to 2000 meters above sea level.
- They can be a problem in several other crops such as chilli, capsicum, cabbage, cotton, celery, tomatoes, beans, cucumber and pineapple.
- We can find thrips in almost any cultivated and weedy plants.

Factors favouring Thrips population: Hot and dry weather favours thrips population and the severity of thrips injury to onion. The possible reason is likely a combination of factors such as shorter generation time and a reduction in mortality from rain and other plant pathogens. Heavy rains washes off the pest from plants. Moreover, water deficit

Thrips populations at base of the onion plant

Onion field infested with Thrips

stress may affect the nutritional quality of plants and also increases attractiveness of these water stressed plants to thrips.

Bionomics of Pest: Life cycle of onion thrips comprises 4 immature stages.

Eggs

- **Size :** Eggs are microscopic and almost impossible to see.
- **Color :** White or yellow.
- **Location :** Eggs are inserted one by one by the females in the plant tissue. Only one end of the egg will be near the surface of the tissue to allow the emergence of immature. Adults prefer to lay their eggs in leaf, cotyledon, or flower tissues.

Nymphs

- Very small, 0.5 to 1.2 mm.
- Thrips body is elongated, elliptical and slender.
- Their eyes have darker coloration and are easy to see.
- Immature thrips have short antennas.
- The difference between immature and adults is that immature do not have wings, so they cannot fly.
- **Color :** White to pale yellow.
- **Location :** The majority of immature thrips are found between the young leaf blades at the top of the plant.
- **Behavior :** Immature prefer to feed on the youngest leaves. If disturbed, they move quickly to find new refuge at the base of the leaves.

Pupae

- **Size and Form :** Very small. Thrips pupae appear as an intermediate form between the immature and the adult. They have short antennae and the wing buds are visible but short & not functional.
- **Color :** Pale yellow to brown
- **Location :** In the base of the plant neck or in the soil.
- **Behavior :** At this stage thrips do not feed.

Adult

- **Size and Form :** Up to 2 mm. Adults have fully developed wings. They have a single longitudinal vein in which there is several hair connected perpendicular to the vein. When at rest, the wings are folded along the back of the insect.
- **Color :** Pale yellow to dark brown
- **Location :** The same as immature, we can find them also in the flowers.
- **Behavior :** Adults are more mobile than immature and pupae because they can fly. They are attracted to yellow & white colors.
- **Size :** Eggs are microscopic and almost impossible to see.
- **Color :** White or yellow.
- **Location :** Eggs are inserted one by one by the females in the plant tissue. Only one end of the egg will be near the surface of the tissue to allow the immature to emerge.

Biology & Ecology

- Completed life cycle in 14 to 30 days.
- When temperatures are over 30°C the life cycle can be shortened to 10 or 11 days.
- The adults may live up to 20 days.
- Thrips do not need to mate for reproduction.
- Females that do not mate will produce only female progeny.
- Each female can produce up to 80 eggs.
- This reproductive aspect is very important because from a single thrips a population can be generated in very short time.

Damage & Importance

- Thrips attack onion and garlic at all the stages of crop growth
- Thrips have a very peculiar feeding behavior.
- They start the feeding by piercing and rasping the leaf surface with their mouth parts to release the liquids from the plant cells.

- In this process, thrips release substances that help predigest the onion plant tissue. Later, with their mouth they suck up the plant content.
- Thrips prefer to feed on the young plant tissue on the newest emerged leaves.
- Plant cannot adequately photosynthesize.
- The plant losses more water than normal through the damaged tissue.
- Plant pathogens penetrate the injured plant easily.
- Bulbs may mature faster and the size becomes reduced.
- More than 60% of the onion crop may be lost.Thrips may also serve as vectors of some viruses and other plant diseases, especially the fungus, purple blotch *(Alternaria porri)* and Iris Yellow Spot virus

Economic threshold

- A reliable treatment threshold has not been developed, however, a threshold of 30 thrips per plant during mid season.
- For small onions producers the recommended economic threshold is 20% of the plants infested with thrips.
- The threshold is 3 thrips per green leaves.
- Cumulative Thrips Days (500- 600 means 50- 60 thrips for 10 days)

Management:

Cultural Methods

- Planting season
- Weed destruction
- Drought stress
- **Colour sensitive mulch :** Alluminium coated mulch repel the pest upto 33 to 68%
- Inter-cropping with maize, carrot may also reduce thrips population
- **Soil fertility :**
  - Lack of adequate soil calcium may invite higher population of thrips
  - High nitrate levels invite thrips

1. Planting season

- No. of thrips can increase rapidly up to 30°C
- At 40°C up to 7 days thrips mortality increases
- At the end of the hot dry season, thrips populations are at their maximum.
- In some places it is better not to plant under these conditions because thrips control is almost impossible.
- If the only crop in the dry season is onions there should be an onion free period (2-3 weeks) before each planting to interrupt the thrips cycle by removing host plants.

2. Irrigation

- Irrigation of the onions is very important to control thrips.
- Use sprinkler irrigation to simulate rainfall and control the thrips.
- If the onion plant is under water stress the thrips damage may be magnified because the plant is losing large amounts of water from the damaged tissue.
- Heavy rainfall caused up to 70% mortality of thrips.

3. Plot location

- Thrips are not good flyers, but they move long distances on the wind.
- Younger plots should be planted upwind of older plots, relative to prevailing winds, to make it harder for the thrips to find the new plantings.

4. Seedlings

- Direct seeding of onions prolongs the growing season in the field and the susceptibility to thrips infestation.
- If the crop is going to be transplanted, the seed-beds should be distant from the old plantings and new plots to be planted.
- It is very important that onion seedlings are clean of thrips before transplanting to the field

Biological Agents:

- Lady bird beetles
- Minute pirate bugs
- Lace wings

- Ground beetles
- Hower flies
- Predatory mites
- Spiders

It is very difficult for predators to find thrips because thrips feed under close fitting leaves.

Chemical Methods

- Because of severe pesticide resistance problems with different pests around the globe, it is very important to use pesticides as little as possible in an IPM programme.
- Eggs & pupae that are usually protected from insecticides
- Fipronil @ 1 ml/ltr. of water and spionsad @1 ml/ltr. offers best control of this pest.
- At high temperature profenophos @ 2 ml/ltr. gives good control.
- Alternate use of chemical groups.
- Spinosad is a recently discovered insecticide, derived from the fermentation of actinomycetes bacteria commonly found in soil.
- The National Organic Board has recommended that spinosad be allowed in organic production.

(2) Onion maggot

Scientific Name: *Delia antique* Meigen. *D. Platura*

Family : Anthomyiidae

Order : Diptera

Description

- Maggot is a pest of onion and do not generally cause economic damage to garlic.
- Onion maggot can cause losses from 20-90% in many temperate regions
- Onion maggot adults are ¼ inch, gray brown, bristly, humpbacked flies.
- Eggs are white, elongate, with characteristic surface ridging and hexagonal pattern.
- The 1/3 inch maggots are legless, cylindrical, tapering at the head and creamy white. They pupate with in a chestnut brown puparia.
- The flies lay eggs in small batches on the soil surface near the base of the seedlings.
- Female mate only once but males are capable of repeated mating. Maggots prefer soils heavy in organic matter where they can survive and move to seeds.

Monitoring

- No monitoring system is available to monitor this pest. However adults can be caught using yellow sticky traps.
- Flies avoid the onion crop during day, prefer to rest in the shade of surrounding foliage.

Management

Cultural Methods:

- Avoid planting in soils that are high in undecomposed matter.
- Avoid planting, where crop rotations are not followed.
- There is no promising natural enemies that are successfully employed for control of this pest at field level.
- Only braconid, *Aphaereta pallipes* and *Staphylinid, Aleochara bilineata* have significantly increased the mortality of onion maggot, but the performance in field is poor.

Biological Control

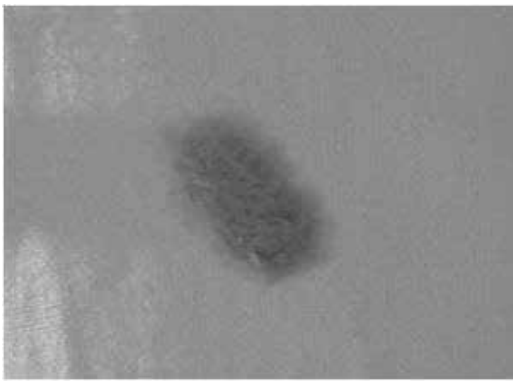
- Ground beetle is an onion maggot predator and establishing grassy refuse stripes in onion crop will enhance the beetle population and reduce the maggot population.
- An entomogenous fungus, *Entomophthora muscae* was reported from Canada Under laboratory conditions the entomophyllic nematodes, *Steinenema faltiae* and Heterorhabditis caused 63.3-100% mortality of *D. antiqua* .

(3) Armiworms

Scientific name: *Spodoptera exigua S. Litura*

Family : Noctuidae

Order : Lepidoptera



Egg mass of Spodoptera litura & damaged onion leaf by larvae

Damage and Importance:

- These are minor pests of onion
- Eggs are laid in groups on the leaf surface. Early instars are gregarious and larvae feed on leaf surface and bore in to the leaf and remain inside and feed. Leaves with big holes and faecal matter are seen on attacked plants. Pupation occurs inside the soil

Management

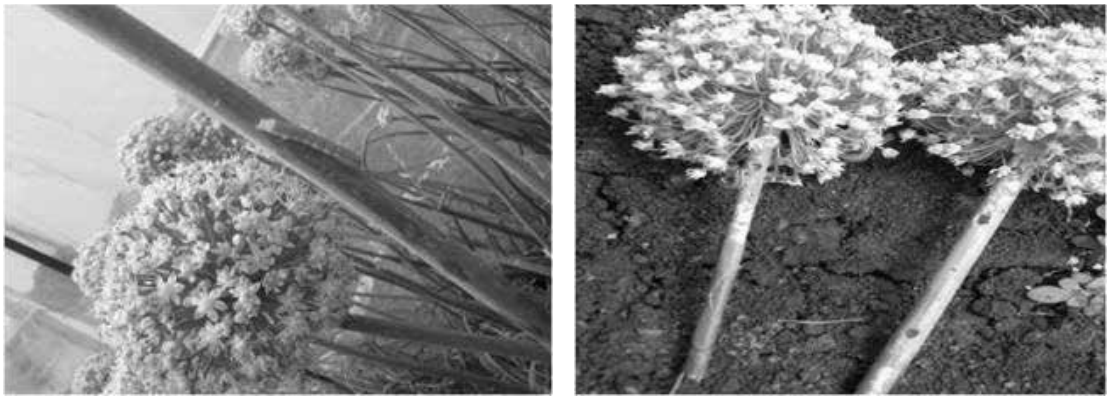
- Specific application of any treatment is not required as the insecticides recommended for thrips control can check this pest also.
- Use of NPV and BT alone and in combination are recommended for control this pest.

(4) Head borer

Scientific name: *Helicoverpa armigera* (Hubner)

Family : Noctuidae

Order : Lepidoptera



Onion seed crop (Umbels) damaged by Helicoverpa larvae

Damage and Importance

- This polyphagous pest occurs sporadically on onion grown for seed.
- Larvae feed inside the stem and move upwards to reach the base of the umbel at early stage of flowering.
- As a result complete drying of flowers and complete loss of seed occurs.

Management

- Specific application of any treatment is not required as the insecticides recommended for thrips control can check this pest also.
- Use of NPV and BT alone and in combination are recommended for control this pest.

(5) Bulb Mites

Scientific name: *Rhizoglyphus* spp. *Tyrophagus* spp.

Description

Bulb mites are shiny, creamy white, bulbous-appearing mites that range in size from 0.02 to 0.04 inches (0.5 to 1 mm) long. They have four pairs of short brown legs and look like tiny pearls with legs. They generally occur in clusters inhabiting damaged areas under the root plate of onion bulbs or garlic cloves. They have a wide host range, feed on many kinds of bulbs, roots, and tubers, and can infest bulbs in storage or in the field. Bulb mites can survive on decaying vegetation in the field until it is completely decomposed.

Damage

Bulb mites damage bulbs by penetrating the outer layer of tissue and allowing rotting organisms to gain entry. This pest is most damaging when plant growth is slowed by cool, wet weather. Bulb mites can reduce plant stands, stunt plant growth, and promote rot of bulbs in storage. On seeded onions, they can cut off the radicle before the plant becomes established.

Management

Cultural Control

- Rapid rotation, from one crop to the next, fosters survival of mites on the leftover vegetation in the soil from the previous crop. Decaying cole crops, especially cauliflower, may harbor very high bulb mite populations.
- Fallow fields to allow complete decomposition of organic matter; this reduces field populations of the mite. Avoid planting successive onion or garlic crops.
- Flood irrigation or heavy rains during the winter may reduce mite levels in the soil. Garlic growers must insist on clean seed cloves. Hot water treatment of seed garlic before planting may reduce mite infestation.
- Sulphur @ 0.5 ml/lit. or Dicofol @ 2ml/lit. as pre sowing and post sowing treatments is effective to manage the mites.

(6) Leafminers

Scientific name: *Liriomyza* spp.

Onion leaves damaged by Leaf minor

Description

Adults are small black and yellow flies. Females puncture the leaf to feed on plant sap and to lay eggs within the leaf tissue. Eggs hatch within 2 to 4 days and the small white to yellow larvae tunnel within the leaf tissue. Larger larvae may feed inside the hollow leaves of onions or garlic, but still produce the characteristic "mines" visible from the outside of the leaf. Larvae exit the leaf upon completion of their development and pupate in the soil or in the leaf axils on plants. Many generations occur each year.

Damage

Damage caused by leaf miners is primarily cosmetic in green bunching onions; contamination by pupae and larvae, however, is a problem. Damage in dry onions and garlic is of little concern unless populations become so high as to prematurely kill foliage.

Management

Cultural Control

Leaf miners attack a wide variety of crops. Close proximity to crops such as lettuce, celery, or spinach will increase the potential for damage by leaf miners in onions. It is also important that fields being planted to onions that were previously in one of these susceptible crops be worked thoroughly and that sufficient time be allowed to pass before planting into these fields to allow pupae in the soil to emerge.

Biological Control

Natural enemies, especially parasitic wasps, are commonly found reducing leaf miner numbers. These parasitic wasps are very susceptible to insecticide sprays, however, and may not be important in fields where insecticides have been used.

Methods of Commercial Hybrid Seed Production in Vegetable Crops

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In the present era of rainbow revolution vegetable seed industries have undergone a sea change both in terms of quality and quantity. With the development in the areas of production, packaging, handling, transportation, marketing and advertising vegetable seed industry is gaining a special attention in the global trade.

As per final data on area and production of horticulture crops by government of India, vegetables alone contribute 59.15 % of total horticultural production with production of 184.40 million tonnes from 10.25 million ha during 2017-18, NHB (2018). This spectacular growth in vegetable production has increased the productivity to 18.00 t/ha and *per capita* availability more than 280 g. This magnificent increase was possible due to development of improved varieties/hybrids and availability of their quality seeds, production and protection technologies through systematic research coupled with large scale adoption by the farmers.

In India *per capita* land resources (0.121 hectare) are shrinking due to the burgeoning population pressure and other needs, therefore, it is imperative to ensure the higher production and productivity per unit of area. Vegetable crops are more productive than other crops, which have potential of providing nutritional security for urban population and in rural tribal areas.

Therefore, to increase production and productivity of vegetable crops, hybrid varieties can play a vital role. In general, hybrid cultivars are preferred because of their high yield potential, vigour, uniformity, disease resistance, stress tolerance and excellent horticultural traits such as long shelf-life and transportation. The steady increase in productivity can be achieved through the use of quality seeds with built in inbred and hybrid vigour, coupled with the application of modern vegetable cultivation technologies and sound government policies. Thus, hybrid vegetable technology is one of the better options. The main reason for low productivity in vegetables and

less commercialization of hybrids in India is certainly due to the non availability of quality seed of improved hybrids for large area of distant places. and the secondly high cost of hybrid seed of different vegetables like tomato, sweet pepper, chilli, cabbage and melons/gourds. Thus, the economical seed production would be boom to the seed industry and vegetable growers. Advantages of F_1 hybrid seeds over traditional varieties are as follows

Why farmers should use F1 hybrid seed?

1. The yield per unit area of F_1 hybrid is significantly high
2. Uniformity in shape and size make hybrid more popular
3. Resistance to biotic and abiotic stress in F1 hybrids leads to more productivity
4. Better keeping quality and resistance to stress are certain additional advantages of growing hybrid vegetables
5. Employment generation through hybrid seed production and cultivation
6. Hybrids have better market acceptability
7. The adoption of F1 hybrid does not require any special skill and farmers of various socio-economic and cultural backgrounds can adopt the new seeds easily.

Hybrids Developed in India

In India, even though the first report of hybrid vigour in chillies came in 1933 from Indian Agricultural Research Institute, the first F1 hybrid variety 'Pusa Meghdoot' of bottle gourd was developed by IARI in 1971. The first F1 hybrid of tomato and capsicum was available for commercial cultivation only in 1973. Since then, there has been an increasing interest in growing hybrids in vegetable crops among the Indian farmers and a large number of hybrids have been developed by public and private sector which led to the increase in productivity of vegetable crops. Till 2016, 477 varieties and 24 major vegetables crops have been identified for cultivation in different climatic zones through AICRP on Vegetable crops of which 151 are hybrids. Among these, 77 (51%) hybrids were released by private sector and rest 74 (49%) by public sector. The number of hybrids identified in different vegetable crops through AICRP-VC has been presented in table-1.

Table 1. F1 hybrids developed in India by public and private sector

Vegetables	Vegetable hybrids developed (Number)			Share of public sector (%)
	Total	Private	Public	
Tomato	39	16	23	41.03
Brinjal	40	27	13	32.50
Chilli	15	10	05	33.33
Sweet pepper	05	01	04	80.00
Okra	13	05	08	61.54
Cabbage	09	06	03	33.33
Cauliflower	07	03	04	57.14
Bottle gourd	05	02	03	60.00
Bitter gourd	04	02	02	50.00
Ridge gourd	02	01	01	50.00
Ash gourd	02	00	02	100.00
Cucumber	05	03	02	40.00
Watermelon	02	01	01	50.00
Muskmelon	02	00	02	100.00
Carrot	01	00	01	100.00
Total	**151**	**77**	**74**	**49**

Singh et al., 2016

There are number of F1 hybrids developed by public sector organization which are popular and multiplied by NSC at national and SSC at state level (table 2) and many private sector companies through MTA.

Table 2. Public sector hybrids in vegetable crops

S. No.	Crop	Hybrids	Source
1.	Tomato	Pusa Hybrid-1, Pusa Hybrid-2, Pusa Hybrid-4, Pusa Hybrid-8, Pusa Divya (Kt-4)	IARI, Delhi
		Arka Rakshak, Arka Ananya, Arka Samrat, Arka Shreshta, Arka Vishal, Arka Vardan, Arka Abhijit	IIHR, Bengaluru
		Kashi Abhiman	IIVR, Varanasi
		Pant Hybrid-1, Pant Hybrid-2, Pant Hybrid-10, Pant Hybrid-11	GBPUAT, Pantnagar
		Rajashree, Phule Hybrid-1	MPKV, Rahuri

S. No.	Crop	Hybrids	Source
2.	Brinjal	DBHL-20 (Long), Pusa Hybrid-5 (Long), Pusa Hybrid-6 (Round), Pusa Hybrid-9(oval), Pusa Anupama (Kt-4) (Long)	IARI, Delhi
		Arka Navneet	IIHR, Bengaluru
		Kashi Sandesh	IIVR, Varanasi
3.	Chilli	CH-1, CH-3, CH-27 (leaf curl resistant)	PAU, Ludhiana
		Arka Meghana, Arka Harit, Arka Sweta	IIHR, Bengaluru
		Kashi Early, Kashi Surkh	IIVR, Varanasi
4.	Sweet pepper	Pusa Deepti, KTCPH-3	IARI
5.	Cucumber	Pusa Sanyog, Parthenocarpic hybrid	IARI
6.	Bitter gourd	Pusa Hybrid-1, Pusa Hybrid-2, Pusa Hybrid-4	IARI, Delhi
	Bottle Gourd	Pusa Hybrid-3	IARI, Delhi
		Kashi Bahar	IIVR, Varanasi
		Pant Sankar Lauki 1	GBPUAT, Pantnagar
		Narendra Sankar-1	NDUAT, Faizabad
7.	Muskmelon	Pusa Rasraj	IARI, Delhi
		Punjab Hybrid-1	PAU, Ludhiana
8.	Pumpkin	Pusa Hybrid-1	IARI, Delhi
9.	Summer squash	Pusa Alankar	IARI, Delhi
10.	Watermelon	Arka Jyoti	IIHR, Bengaluru
11.	Cauliflower	Pusa Kartik Sankar, Pusa Hybrid-2, Pusa Snowball Hybrid-1	IARI, Delhi/ R.S Katrain
12.	Cabbage	Pusa Cabbage Hybrid-1	IARI, Delhi
13.	Carrot	Pusa Vasudha (red colour), Pusa Nayanjyoti (orange colour)	IARI, Delhi/R.S Katrain
14.	Onion	Arka Lalima, Arka Kirtiman, Arka Bhima	IIHR, Bengaluru
15.	Okra	Kashi Bhairav	IIVR, Varanasi
		Arka Nikitha	IIHR, Bengaluru
16.	Ashgourd	Pusa Shreyali and Pusa Urmi	IARI, Delhi
17.	Sponge gourd	Pusa Shrestha	IARI, Delhi

Methods of Hybrid Seed Production

Availability of economical method for producing large-scale F1 seeds has gained momentum in last few decades which ultimately determines the commercial viability of the hybrid varieties. A number of mechanisms and methods have been evolved for the development of hybrids in vegetable crops, however, only selected once are utilized to develop commercial hybrids of specific vegetables.

The most commonly utilized mechanism or methods for hybrid seed production in commercial vegetables are presented in table 3.

Table 3. Methods/Mechanism of hybrid seed production in commercial vegetables

Methods/Mechanism		Commercially exploited in vegetables
Hand emasculation and hand pollination	:	Tomato, brinjal, sweet pepper, okra, chilli, cherry tomato
Removal/pinching of male flowers and hand pollination	:	Bitter gourd, bottle gourd
Removal/pinching of male flowers and natural pollination	:	Bitter gourd summer squash
Protection of female flower bud and hand pollination	:	Bitter gourd, bottle gourd and pumpkin
Male sterility and hand pollination	:	Cabbage, Tomato, chilli, sweet pepper
Male sterility and natural pollination	:	Onion, carrot cabbage, cauliflower, carrot, radish , muskmelon, chilli, okra
Self incompatibility and natural pollination	:	Most of the cole crop like broccoli, cabbage, cauliflower
Gynoecism and natural pollination	:	Cucumber, musk melon, bitter gourd
Induction of male flower in pollen parent and manual pollination	:	Parthenocarpic cucumber hybrid (Gynoecious and gynoecious)
Use of plant growth regulators	:	Summer squash

Among the above mentioned methods the following are commercially utilized for economical hybrid seed production.

Hand emasculation and hand pollination

The traditional method which is used for hybrid seed production is hand emasculation and pollination. This method is cost effective only in those crops where number of seed per pollination is more and per hectare seed requirement is less, such as brinjal, tomato,

cucurbits. This technique is applicable for limited scale production, since lot of trained labour are required in pinching, pollen collection and hand pollination

Protection of female flower bud and hand pollination

Looking in to cost of labour required for searching and removing male flower, the most of the hybrid seed company are now a days only protect female flower bud by butter paper bag and hand pollinate. The technique used in bottlegourd, pumpkin and bitter gourd.

Use of gynoecious sex form

The gynoecious sex form have been commercially exploited in hybrid seed production of cucumber (Pusa Sanyog) at IARI R.S. Katrain and in muskmelon (MH-10) at PAU, Ludhiana.In In hybrid seed production female and male rows are planted in 4:1 ratio. The female (seed parent) bear only female flowers and pollition in done by insect (honeybee). To ensure the good fruit and seed recovery, the sufficient population of honeybee 1 to 1½ colony of medium size has to be kept at the boundary of seed production plot to boost the amount of crossing. The parental lines i.e. male parent maintained by selfing (mixed pollination) and rouge out undesirable plants before contamination take place. The female lines i.e. gynoecious lines maintained by inducing the staminate flower through the sprays of silver nitrate 200 ppm at two to four true leaf stage and then selfing is carried out. It was observed that 10-11 male flowers appear per 100 nodes. IARI has developed gynoecious lines in bitter gourd and ridge gourd which may be exploited for hybrid development and seed production,

The performance of gynoecious lines is unstable under high temperature and long photo period condtions because of their thermo-specific responses for gynoecious stability. That is why the gynoecious cucumber did not receive much attention in the tropical countries. However, few true breeding tropical gynoecious lines in cucumber and muskmelon have been developed at IARI. As a result of development of true breeding line, muskmelon hybrid Pusa Rasraj was developed. These homozygous gynoecious lines are maintained by using GA3, 1500ppm or silver nitrate 200-300 ppm or sodium thio-sulphate 400 ppm to induce staminate flowers at two and four true leaf stage. Homozygous lines are planted in strict field isolation. The gynoecious lines are crossed with monoecious male parent to produce F_1 hybrid.

Hybrid seed production using plant growth regulators

This method of hybrid seed production has been exploited in cucumber and squash. Specific chemicals are known to induce femaleness and maleness as desired. The spraying of ethrel (2-choloro-ethyl-phosphonic acid) 200-300 ppm at two and four true leaf stage and another at flowering is useful for inducing the female flower successively in first few nodes on the female in bottle gourd, pumpkin and squash for F_1 seed

production. The row of male parent is grown side by the side of female and natural cross pollination is allowed. In the absence of insect, hand pollination is possible when two sexes are separate. Four to five fruit set at initial nodes are sufficient for hybrid seed. The complete suppression of male flowers in squash can be achieve at higher concentration of (400-500 ppm) of ethrel applied twice and has made hybrid seed production comparatively easier and nearly 56% of toal squash seed produced in USA is of F_1 hybrid. The other chemicals like GA_3, (10-25 ppm) in cucumber, MH-(100 ppm), ethephone (600 ppm) in squash induces female flowers

Genetical Tools for Economic Hybrid Seed Production

Male sterility

Male sterility is a condition in normally bisexual plants (monoecious as well as hermaphrodite) when no viable pollen is formed. As the importance of F_1 has increased, male sterility has proved an asset, particularly in crops like onion and carrot which has small flowers making hand emasculation tedious. Large-scale hybrid seed production sometimes remains handicapped because of high labour costs, unavailability of trained labour at crucial times, and bad weather conditions. Public sector in most of the developed nations, has successfully utilized male sterility system in several vegetable crops to produce hybrid seeds at commercial scale. Similarly, private sector is also involved in the development of male sterile based hybrids of the important temperate and tropical vegetables.

Male sterility and their utilization in hybrid seed production

Kaul (1988) has classified male sterility into two major groups: genetic (spontaneous or induced) and non-genetic (induced) male sterility. On a phenotypic basis, genetic male sterility has been divided into three classes (i.e. sporogenous, structural and functional) and non-genetic male sterility as chemical, physiological and ecological male sterility. The type of male sterility, which has commercially been exploited in vegetable crops are

1. Genetic male sterility
2. Cytoplasmic male sterility
3. Genetic-cytoplasmic male sterility

1. Genetic male sterility

Genic male sterility is generally governed by recessive nuclear genes. It has been reported in cabbage, cauliflower and other members of the cole group as well. This type is generally controlled by single recessive nuclear alleles. This allele is represented by 'ms'

because 'ms' is recessive, only the homozygotic genotype "msms" is sterile, while the heterozygotic genotype "Ms ms" and the homozygotic "Ms Ms" are fertile. The hybrid seed is produced by crossing a male line that is male fertile and homozygous for the dominant form of the MS allele with a female line that is male sterile, i.e. homozygous for the recessive form of ms. The hybrid seed is completely heterozygous for ms, and therefore 100% male fertile.

Limitation of GMS

1. More tedious process of maintenance
2. Non-availability of suitable marker genes among vegetable crops, GMS has been utilized commercially
3. In crops like tomato, brinjal, pea etc, which are highly self pollinated, free out crossing is prohibitive, thus leading to poor seed and/or fruit set.

2. Cytoplasmic male sterility

In this system cytoplasm of the cell determines the male sterility system. Since the cytoplasm of a zygote comes primarily from the egg cell, the progeny of such male sterile plants would always be male sterile. This type of male sterility can only be utilized where vegetative part is economical such as carrot, radish, cabbage etc. Cytoplasmic male sterility can be transferred easily to a given strain by using that strain as a pollinator (recurrent parent) in the successive generations of the backcross programme.

Limitation of Cytoplasmic male sterility

1. Cytoplasmic male sterility can be utilized for producing hybrid seeds in those vegetables where the vegetative part is of economic importance
2. Cytoplasmic male sterility (CMS) is sensitive to environmental factors, e.g. a line may be completely male sterile in one environment and may have partial fertility in another. This phenomenon may lead to mixture of selfed seed in an otherwise hybrid seed

3. Cytoplasmic-Genetic male sterility (CGMS)

Once dominant restorer (*Rf*) gene (located in nuclear genome) responsible for pollen fertility of a cytoplasmic male sterile line is identified, it is commonly known as cytoplasmic-genic male sterility (CGMS). The fertility restorer gene, *Rf*/*Rf* is dominant and is found in certain strains of the species or may be transferred from a related species through back crossing. The sterility is determined by the interaction of nuclear genes and cytoplasm but none of them singly can control sterility. This type of male sterility has successfully been utilized in carrot, onion, beetroot, chilli, capsicum etc. Cytoplasmic-genetic male

sterility can be maintained by crossing a cytoplasmic male sterile line (S*rf*/*rf*) or A line with the pollinator strain (N *rf*/*rf*) B line. For hybrid seed production, two to three rows of line A (S *rf*/*rf*) are alternated with one row of line C, which is generally expected to be N *Rf*/*Rf*. The seed is harvested from line A for use as the commercial hybrid seed.

Limitations Cytoplasmic-genetic male sterility

1. Its use is restricted to specific species because of certain limitations, such as non-availability of CGMS in many crops and their wild relatives; need of fertility restorer allele in fruit-producing vegetables

2. Breakdown of male sterility in particular environments; highly unstable sterile cytoplasm in several cases;

Utilization of male sterility for commercial hybrid seed production in selected vegetables

Chilli: Among the genetic emasculation tools, both genetic male sterility (GMS) and cytoplasmic-genetic male sterility (CMS) have been employed in hybrid seed production of chillies The Punjab Agricultural University (PAU) has developed the MS-12 line, which carries genetic male sterility (GMS) controlled by recessive gene (msms). By using this male sterile line (MS-12), PAU has released two chilli hybrids: Chili Hybrid-1 (CH-1) and Chilli Hybrid-3 (CH-3). Farmers in Punjab are producing seeds of these hybrids. A total of nine sets of A and B lines are being maintained at ICAR-IIVR and two promising CGMS-based hybrids Kashi Surkh and Kashi Tej habe been released. The Indian Institute of Horticultural Research (IIHR), Bangalore India, has also developed hybrids in chilli based on the CGMS system, i.e. Arka Meghna (MSH-172), MSH-149 and MSH-96.

Carrot: The hybrid development in carrot has been facilitated by cytoplasmic genetic male sterility (CGMS), which is of two types as described by Riggs (1987): brown anther type and petaloid type. The brown anther (ba) type of sterility, results in anther degeneration and sterility and is present in all cultivated orange-coloured open pollinated varieties. The phenotype is characterized by deformed, brown anthers without functional pollen caused by a genetic block in meiosis. The petalloid phenotype is characterized by a transformation of anthers into petals or petal-like structures which are unable to produce functional pollen. It was called the Cornell cytoplasm and used to produce the majority of hybrid carrots in the United States. In India, at the IARI regional station, Katrain (H.P.) also transferred petaloid CGMS into Nantes types and crossed it with the indigenous variety 'Pusa Yamdagini'. As a result, hybrid Pusa Nayanjyoti has been identified for release from the Delhi state seed subcommittee in 2009. The IARI, New Delhi has established CGMS system in different genetic backgrounds of tropical carrot and developed different hybrid combinations

Onion: In onion, male sterility is due to interaction of cytoplasm and nuclear gene, i.e. cytoplasmic genetic male sterility (CGMS). Worldwide more than 50% onion varieties currently cultivated are F1 hybrids derived from S-cytoplasm. In India, the work gained momentum in the eighties at IIHR (Bangalore), IARI (New Delhi) and MPKV (Rahuri). At IARI, male sterility was found in a commercial variety Pusa Red. Only two hybrids, Arka Kirtiman and Arka Lalima have been released by IIHR after development of CGMS lines along with the maintainer. The first F1 hybrid, VL- 67, was released in 1973, and thereafter, an improved F1 crossm "BYG-2207 x Almora Selection-2", was identified at VPKAS, Almora in 1976 and these hybrids were 276 developed using exotic CGMS lines.

Cucurbits: There are several male sterile types are identified, but commercial exploitation is still lacking. Among the cucurbits male sterility is commercially exploited and utilized in musk melon. Five male sterile genes (ms-1, ms-2, ms-3, ms-4, and ms-5) have been identified in melon (*Cucumis melo* L.) and all of them are recessive and non-allelic. In India, male-sterile gene ms-1 was introduced in 1978 and used to release two commercial cultivars 'Punjab Hybrid' (Nandpuri et al., 1982) and 'Punjab Anmol' (Lal et al., 2007).

Cole Crops: In India this sterile cytoplasm from broccoli was transferred and established in three different maturity genetic backgrounds of Indian cauliflowers viz., early, mid and mid late through hybridization. The curd yield is increased 40-75% compared to SI system from different maturity groups. Recently Ogura based CMS lines developed in snowball cauliflower viz., Ogu1A, Ogu2A and Ogu3A for hybrid development in cauliflower. In India, IARI regional station Katrain develops two cabbage hybrids H-64 and KCH-4 using cytoplasmic male sterility.

Tomato: Male sterility was for the first time used in tomato hybrid seed production by Rick (1945) and up to the present this phenomenon is still recognized as a useful trait in breeding programs that address facilitation of the process of hybrid seed production. More than 55 male sterile (ms) alleles causing sporogenous, structural and functional sterility have been reported. There are four types (Pollen sterile, Stamenless, Positional sterility and Functional sterility) of male sterility in tomato. Each one is governed by a single recessive gene. Functional male sterility has been utilized for development of a F1 hybrid Pusa Divya at IARI, New Delhi. A study has also been conducted functional male sterility in tomato and its application in hybrid seed production in functional male sterile line "Pusa Divya" hybrid by Manjunatha and Tomar (2009) and revealed that repeated pollination of same stigma produced higher fruit set and seed yield per fruit compared to once pollinated. Fruit set per cent was same when pollination was performed with freshly collected pollen, extracted pollen, one day ambient stored pollen and 8 day stored pollen at 40^0 c.

Self-incompatibility

Self-incompatibility refers to the inability of a plant with functional pollen to set seeds when self pollinated. The process of pollen germination, pollen tube growth, ovule fertilization or embryo development is restricted at one of its stages and consequently no seeds are set. Among the cruciferous vegetables like cabbage, cauliflower, broccoli, radish etc., self-incompatibility (sporophytic) mechanism is being utilized for hybrid seed production. The genetics of the self-incompatibility system in the cruciferous crops are so well developed that they consist of a series of genes (loci) and alleles. For hybrid seed production both the parental inbreds should have two different *S* alleles for strong self-incompatibility (in case of single cross hybrid).One S.I. inbred is used as female parent and a good pollinator (an open pollinated variety) as male to develop top cross hybrid, while four S.I. inbreds having altogether different *S* alleles are used to produce double cross hybrids.

In case of radish, F1 hybrids are advantageous over OP varieties with respect to uniformity in growth and root development, temperature tolerance, earliness, and length and diameter of root.But the purity of hybrid seeds are in doubtful due to presence of sib-seeds produced on SI line during environmental aberrations, and makes it unsuitable. Although it is a widely grown crop; unfortunately no one hybrid from public sector is in cultivation

Basic steps in the use of SSI

1. Identification of self-incompatible plants in diverse population/genotypes
2. Development of homozygous self-incompatible lines
3. Identification of S-alleles in the homozygous self-incompatible lines
4. Establishment of inter-allelic relationships among the S-alleles Identifying the best combining lines
5. Maintenance of parental self-incompatible lines for commercial hybrid seed production

Maintenance of homozygous SI inbreds

1. Bud pollination / Sibmating
2. Treatment with CO_2 gas (CO_2 enrichment)
3. Tissue culture using meristem
4. Sodium chloride sprays
5. Removal of stigmatic surface or whole stigma, useful in sporophytic system.
7. Exposure to high temperature. Double pollination

Hybrid seed production under protected conditions

Quality hybrid seed production of vegetable crops face tremendous challenges like lack of sufficient isolation, insects, diseases and a virus free environment in the production of disease free, healthy and genetically pure seed for commercial cultivation. Compared to conventional practices, protected cultivation can deliver higher seed yield with better quality (Tomar and Jat, 2015). Insects and viruses are the most devastating problems for quality seed production in most of the vegetable crops in open fields, and if the insect vectors are checked by using protected structures this problem could be solved with less application of pesticides.

Protected structure be utilized for healthy nursery raising of vegetables for quality seed production may healthy nursery raising of vegetables for quality seed production, insect proof net house under tropical climate is suitable for hybrid seed production of tomato, sweet pepper, chilli, okra, brinjal and cucurbits as compared to open field condition (Jat *et al*., 2015; 2016). Naturally ventilated green house under subtropical climate is also suitable for hybrid seed production, where the seed yield is usually 2-3 times more over open field, but the cost of seed production is only 1/3 of the seed produced under semi-climate controlled green house condition (Singh and Tomar, 2015). The major advantages of hybrid vegetables seed production under protected conditions are:

1. Higher seed yield (generally 2-4 times more) and seed quality as compared to open field
2. Requirement of large isolation distance in cross pollinated vegetables can be minimized under protected conditions.
3. Problem of synchronization of flowering in parental lines can be minimized.
4. Seed production under adverse climatic conditions is possible where it is not possible in open field conditions.
5. Field standards could be enforced well under protected conditions and healthy virus free seed crop can be grown, which is very difficult under open field conditions.
6. Training, pruning and hand pollination practices are very easily manageable under protected conditions compared with to field seed crop.
7. Hybrid seed production can also be possible even under saline and acidic soil conditions by using soil less media.
8. Virus free healthy seedling production of the parental lines is possible under protected conditions.

9. Emasculation of female parents is not required as there are no insect pollinators inside the protected structures.

10. Seed crops will not be damaged by un-seasonal rains at the time of their maturity unlike open field seed crops.

11. Seed viability and seed vigour could be extended through better nutrient management in seed crops under protected conditions

Use of Honeybee in Hybrid seed production

Honeybees are the main pollinators in most of the cross pollinated vegetable crops. A large number of species of honeybees have been conserved and utilized for their services for pollination of various crops in the world. In the Asia, there are ten species of honeybees are to be considered and could be exploited for pollination in different agro-climatic conditions. The four main species namely *Apis dorsata* Fab., *Apis cerana indica* Fab., *Apis florea* Fab and *Apis mellifera* Lin have been exploited in Indian conditions. Honeybees are used for Multiplication of inbred lines under cages and hybrid seed production. Number of colonies required for pollination depends upon density of crop stand,total number of flower in each plant, duration of flowering and strength of bee colonies. In general 02 colonies containing 5000 to 6000 bee per hive of *Apis mellifera* per hectare of crops in bloom are recommended for sufficient and efficient pollination. Considering smaller size of *Apis cerena* and its shorter flight range 04-05 colonies per ha is recommended.

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Development of Potato Varieties for Processing Industries - An Overview

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Potato (*Solanum tuberosum* L.) is Potato is the third most important food crop in the world after rice and wheat and is very important for human consumption. Potatoes are considered as a non-fattening, nutritious and wholesome food, containing carbohydrates (16%), proteins (2%), minerals (1%), dietary fibres (0.6%) and is a good source of vitamin C and antioxidants. The diversified uses of potato tubers includes as table, processed, livestock feed and industrial (starch and alcohol) purposes. Potatoes can be consumed in many forms, including baking, boiling, roasting, frying, steaming, and microwaving. Potatoes can be served in any course of a meal from salads, snacks and soups to the main course in which they can figure either as an accompanying side dish, or as the main dish itself.The worldwide utilization of potatoes is moving from fresh to processed potato products such as mashed and canned potatoes, fries, chips (Fig.1), and ready meals.

In India, about 68% of potatoes are utilized for table purpose, 7.5% for processing; 8.5% for seed and remaining 16% produce goes waste due to pre and post-harvest handling. Nearly 90% potatoes are grown in North Indian plains during winter season and harvesting is followed by hot summer, which makes it difficult to store potatoes under ordinary conditions. The slight increase of area, adoption of high yielding varieties and favourbale weather conditions often leads to over production. To bring stability in prices and avoid the periodic glut situations, it is essential to apportion a part of the potato acreage for production for value addition or processing industry. Further, growing urbanization, rise in per-capita income, increase in number of working women, changing food habits, preference for ready-to eat snacks and expanding tourism have made potatoes to travel from kitchen and dining tables to pouches and packets liked by everyone. Processed products are opening up new market avenues in the national and international markets, and as a result, the farmers are finding it highly remunerative to grow processing varieties of potatoes. Besides, dehydrated chips, cubes and other

products can be easily prepared at the small scale industry level and can provide employment to the rural youth and village women. Value addition of potato not only contributes to crop diversification, improve the farm incomes and nutrition but also provide value export and additional employment.

Potatoes for Processing

Potato processing is highly industrialized, technologically advanced, and market driven. The quality of processed products and the economic success of industry, however, depend on the availability of potato raw materials round the year. This means that the availability of suitable cultivars, potato yield, quality in its various aspects during the growing season, and good post-harvest (storage) performance are of utmost importance for the potato processing industry. Processors organize their own potato supply (chain) via contracts and direct contact with farmers. They supply seed potatoes, deliver advice and services to farmers in growing and storage practices. The quality parameters of the processed products as required in the market are translated in potato raw material derived from potato growers. These are adequate tuber size or length for French fries, shape, high dry matter, and low reducing sugar content for acceptable end product colour. In India, potato processing industry mainly comprises four segments: potato chips, French fries, potato flakes/powder and other processed products such as dehydrated chips, *Alu Bhujia, Samosa,* and *Tikkis*. However, potato chips still continue to be the most common and popular processed product

Quality Requirements of Potatoes

Quality is related to visual appearance, culinary preference of the consumer, or ability to meet market specifications. Tuber size, shape, appearance, absence of diseases or defects, flavor and texture determines the quality of the produce for various purposes. On the basis of dry matter and texture, potatoes can be used for different purposes (**Table 1**). A mealy texture is associated with high solids and a waxy texture with low solids. Potatoes containing more than 20% dry matter content with mealy texture are preferred for fried and dehydrated products, while small size potatoes containing dry matter between 18- 20 % with waxy texture are preferred for salad making and canning. Specific characteristics in potato varieties are required for different purposes and are given in **Table 2**. Low glycoalkaloids content (<15mg/100 gram fresh tuber weight) and ability to withstand cold induced sweetening are added advantages. The important quality traits and their importance to users are given in **Table-3**.

Table 1. Relationship between tuber dry matter and optimum use (Mosley and Chase, 1993)

Specific gravity	Dry matter %	Texture	Typical uses
Below 1.060 (very low)	Below 16.2	Very soggy	Pan frying, salads, canning
1.060-1.069 (low)	16.2-18.1	Soggy	Pan frying, salads, boiling, canning
1.070-1.079 (medium)	18.2-20.2	Waxy	Boiling, mashing, fair to good for chip processing and canning
1.080-1.089 (high)	20.3-22.3	Mealy, dry	Baking, chips, frozen French fry, some cultivars tend to slough when boiled
Above 1.089 (very high)	Above 22.3	Very mealy or dry	Baking, frozen French fry, chip, tendency to produce brittle chips and to slough when boiled

Table 2. Requirement of potato varieties for different purposes (Luthra *et. al*. 2004)

Characters	Use requirements					
	Seed	Table potatoes		Processing		
		Boiled	Baking	French fries	Chips	Flakes
Tuber shape	Round/ ovoid	Round/ ovoid	Round/ ovoid	Oblong/Long-oval (>75-110 mm)	Round (45-85 mm)	Oval/Round (30-85 mm)
Skin color	White/ yellow/ red	White/ yellow/red	White/ yellow /red	White/yellow/ red	White/ yellow/red	White/ yellow/red
Eye depth	Shallow/ medium	Shallow/ medium	Shallow/ medium	Shallow	Shallow	Shallow
Flesh color	White/ yellow	White/ yellow	White/ yellow	White/yellow	White/ yellow	Whit-cream
Texture	Waxy/ mealy	Waxy	Mealy	Mealy	Mealy	Mealy
Uniformity	High	High	High	High	High	High
Defects	Minimum	Minimum	Minimum	Minimum	Minimum	Minimum
Dry matter (%)	18-22	18-20	>20	>20	>20	>20
Reducing sugars*	NA	NA	NA	<150mg	<100mg	<150mg
Phenols	NA	High	High	Less	Less	Less
Glycoalkaloids*	< 15mg	< 15mg	< 15mg	< 15mg	< 15mg	< 15mg
Keeping quality	Good	Good	Good	Good	Good	Good
Damage resistance	High	High	High	High	High	High

*mg/100g fresh tuber weight

Table 3. Quality characteristics of importance to processor and consumer and relative importance to each: H = High, M = Medium, L = Low priority (Dale and Mackay, 1994)

Character	Processing	Table use
Tuber defects	H	H
Damage external	M	H
Damage internal	H	M
Glycoalkaloids	H	H
Greening	H	H
Nutritional value	H	H
After-cooking blackening	M	H
Texture	M	M
Enzymatic browning	H	M
Sugar content	H	L
Dry matter	H	L
Flavour	M	H

Morphological Attributes

Tuber size, shape and eye depth: The tubers of 45-85 mm are considered ideal to obtain the desirable size of chips. Round shape is preferred to produce uniformly round chips; tubers with ovoid shape can also be used for making chips. For making good quality French fries, the oblong or long oval (75-110 mm) tubers are desired while for flakes, round to oval shape (30-85mm) is desirable. For canning, small tubers of round to ovoid shape are suitable. Processing varieties in general should possess tubers with shallow or fleet eyes so that peeling losses remain at low levels.

Tuber defects: An internal or external defect of potato affects the quality of finished products. External defects may be due to undesirable shape or size, knobbiness, cracking, decay, greening, etc. Internal defects are imperfections occurring within the tubers, such as hollow heart, brown centre, internal brown spots (IBS) etc. These may be caused by physiological or pathological reasons. Higher defects in the raw material increases the labor requirement during sorting of tubers and ultimately enhances the operational cost apart from reducing the quality of product.

Biochemical Attributes

Tuber dry matter and specific gravity: On an average, potato contains 80% of

water. Tuber dry matter or solids is positively correlated with tuber specific gravity. Dry matter content of tubers is the most important character which determines the quality and yield of fried and dehydrated products. Potatoes with high dry matter content are preferred for preparation of fried and dehydrated products. Dry matter content of 18-20% is considered acceptable for canning but for chips, French fries and dehydrated products it should be more than 20% or > 1.080 specific gravity. Higher dry matter content or solids content result higher recovery of processed product, lower absorption of oil, lesser energy consumption, and crispy texture of the product and ultimately lower the risk of obesity.

Reducing sugars: The reducing sugars (glucose and fructose) present in tubers play a critical role in determining color of fried products like chips and French fries. On frying at high temperatures, sugars react with amino acid groups of nitrogenous compounds giving rise to dark colored compounds and the reaction is known as 'Maillard reactions'. This results in a dark colored, bitter tasting potato product. Besides undesired color and flavor of fried products, 'Maillard reactions' is also related to formation of acrylamide, which is considered a potentially toxic compound. The glucose content of the tubers seems to be the most important factor in determining fry color, but this can be more accurately predicted when fructose content is also taken into account. Sucrose (non-reducing sugar) levels do not correlate well with either of the hexose sugar levels or fry color. Reducing sugars content below 100 mg/l00g fresh tuber weight is acceptable for producing chips. However, for French fries and dehydrated products reducing sugars content up to 150 mg/l00g fresh tuber weight is acceptable.

Phenols: In addition to the discoloration of fried products, tubers show enzymatic discoloration and after cooking discoloration. Enzymatic discoloration occurs when the potatoes are peeled, cut or injured. Some of the constituents e.g. polyphenols present in the tubers react with oxygen (air) and forms o-quinones and ultimately lead to brownish pigment. This type of discoloration can be prevented if potatoes are not exposed to air and are immersed in water.

Glyco-alkaloids: Cultivars vary with respect to their inherent glycoalkaloid content; at lower levels it is suggested that they may enhance potato flavour, but at higher concentration (above 15 mg/ 100g fresh weight) they impart bitterness and levels above 20 mg/ 100g fresh weight are considered unsuitable for human consumption resulting in symptoms typically associated with food poisoning.

Other attributes: Potatoes with special attributes like coloured skin/flesh having more anthocyanins (Fig.1), better taste or texture, nutritionally superior (zinc and iron rich, anthocyanin/carotene/antioxidant rich) or having low glycemic index are becoming popular. The Glycemic Index (GI) is a numerical scale used to indicate how fast and

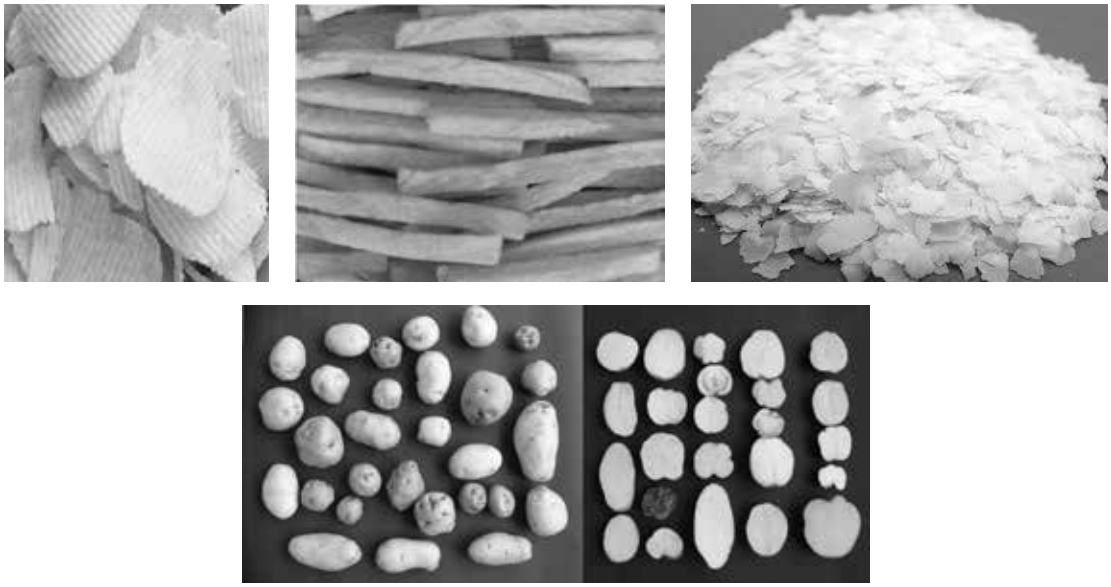

Figure 1: *Potato products-chips, French fries, flakes and specialty potatoes*

how high a particular food can raise our blood glucose (blood sugar) level. A food with a low GI will typically prompt a moderate rise in blood glucose, while a food with a high GI may cause blood glucose level to increase above the optimal level. Foods are characterized into low (≤56), medium (56-69) and high (≥70), according to GI. Glycemic index values for potato vary widely from a low of 23 to a high of 111 (Lynch *et al.,* 2007). The variability in glycemic index values among various potato genotypes/ varieties also exists and need to be exploited for promoting genotypes with low GI. These specialty potatoes fetch premium prices in market thus can be potential value added products in coming future.

Colour of processed products: The colour of the fried product (1-10 scale: 1- very light and desirable colour, and 10- dark and undesirable colour) is determined by frying of chips/fries in hot oil at 180°C till the bubbling is over). The colour up to 3 is desirable for chips and colour up to 4 is desirable for French fries.

Development of Potato Varieties for Processing Industry in India

In India till 1989, all the varieties were bred for consumption as fresh potato. Long day adapted European processing varieties were not successful in India, as they were not suited to short winter days. Some of the varieties like Kufri Chandramukhi, Kufri Jyoti and Kufri Lauvkar were used by the chipping industry from the produce of crop grown

in warmer areas where night temperatures are relatively high (around 10^0 C). Therefore, despite large quantities of potato available in the market, the availability of potatoes for processing was poor.

Keeping in view the demand of quality raw material for processing, ICAR-Central Potato Research Institute launched a breeding programme in 1990 for developing indigenous processing varieties and in the year 1998 first two processing varieties, Kufri Chipsona-1, Kufri Chipsona-2 were released in India. Availability of these varieties and the standardization of elevated temperature (10-12 °C) storage technology for keeping potatoes for processing resulted in rapid development of potato processing industry in the country. In the year 2006 Kufri Chipsona-3 was developed with higher proportion of defects free processing grade tubers. After the development of Kufri Chipsona-3, the efforts were directed to develop a processing variety suitable for hills which could fulfill the demand of raw material for processing industry after July/August. The produce of the popular variety of hills, Kufri Jyoti could not meet the processing standards due to poor and inconsistent quality of tubers and breakdown of late blight resistance. This has led to the development of variety Kufri Himsona suitable for the hills in 2008 which ensures off season supply of raw material to the processing industry.

Non-availability of specialized processing variety for French fries was another impediment for the processing industry. The demand of French fry was being met either by importing frozen fries or preparing French fries from indigenous variety Kufri Chiposna-1 which produced low French fry grade tuber yield. Keeping in view the long felt demand of French fry variety, the institute developed and released Kufri Frysona for north Indian plains in 2009.

All the indigenous processing varieties in the country were of medium to long duration (100-110 Days), therefore, the target was focused on development of early bulking late blight resistant processing varieties required for Karnataka, West Bengal and Madhaya Pradesh. The region specific processing early variety Kufri Chipsona-4 was developed and released in 2010 for plateau region of Karnataka, West Bengal and Madhya Pradesh.

Due to late maturity of Indian French fry variety Kufri Frysona, demand was felt to develop the French fry variety with medium maturity group producing optimum processable grade yield. The effort led to recommendation of advanced potato hybrid MP/4-578 in 2018.

The salient features of the processing varieties (Fig. 2) are described below.

Kufri Chipsona-1 (MP/90-83): The variety is a selection from the progeny of the cross CP2416 x MS/78-79. The female parent CP 2416 was the Mexican genotype MEX

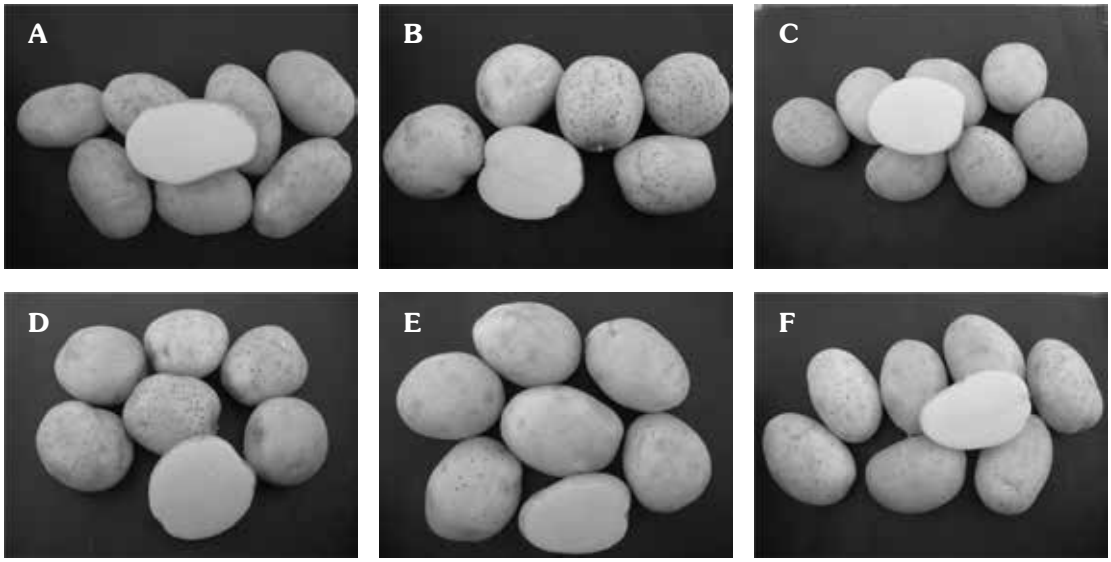

Figure 2: *Indigenous potato processing varieties developed by ICAR-CPRI: Kufri Chipsona-1 (A), Kufri Chipsona-2 (B), Kufri Chipsona-3 (C), Kufri Chipsona-4 (D), Kufri Himsona (E) and Kufri Frysona (F)*

750826, while the male parent - 'was from Indian potato breeding programme which involved Kufri Jyoti and EM/H-1601 in its parentage. Its dry matter content is 20-23% and reducing sugar content is 10-75 mg/100 g fresh weight. The variety yields processing grade tubers to the tune of 60-75%. The variety has good late blight resistance and is well adapted to Indo-Gangetic plains. The tubers possess excellent keeping quality. The variety is suitable for making chips, French fries and flakes.

Kufri Chipsona-2 (MP/91-G): The variety is a selection from the progeny of the cross CP2346 (F-6 from Peru) x QB/B 92-4. The female parent CP2346 is an accession from the germplasm collection received from International Potato Centre, Lima, Peru, while the male parent is from an earlier breeding programme involving in its parentage an Indian variety Kufri Red and the variety Navajo from USA. The tubers of this variety have reducing sugars in the tune of 30-100 mg/ 100 g fresh weight and dry matter content is 22-24%. The variety has high degree of late blight resistance. The processing grade percentage is 65-75 and is highly suitable for chip making.

Kufri Chipsona-3 (MP/97-583): The variety is a selection from the progeny of the cross Kufri Chipsona-2 x MP/91-86. The female parent MP/91-86 is a promising selection from the processing breeding programme. The tubers of this variety have reducing sugar content of 10-100 mg/100 g fresh weight and dry matter content 20-23%. The variety has moderate resistance to late blight and is suitable for chips and flakes preparation. The variety yields reasonably good process grade tubers to the tune of 70-80 %.

Kufri Himsona (MP/97-644): The variety is a selection from the progeny of the cross MP/92-35 x Kufri Chipsona-2. The male parent MP/92-35 is a selection from processing breeding programme. The variety is released for growing in hilly regions of the country. The tubers have dry matter content of 21-24% and reducing sugars 10-80 mg/ 100 g fresh weight. The variety has a high degree of resistance to late blight. The variety is suitable for chips and flakes making

Kufri Frysona (MP/98-71): The variety is selection from the progeny of MP/90-30 x MP/90-94. It produces attractive white skinned, oblong to long shaped tubers with shallow eyes and white flesh. Tubers do not show deformities like knobbiness in Kufri Chipsona-1. It possesses very good field resistance against late blight disease and has reasonably good frost tolerance. It is a good keeper under country store conditions and possess longer tuber dormancy period of more than 8 weeks. It possesses high tuber dry matter and very good quality French fries can be prepared. The industrial testing has shown the superiority of this hybrid for French fry making in terms of taste, texture and colour.

Kufri Chipsona-4 (MP/01-916)**:** The variety is selection from the progeny of cross Atlantic x MP/90-32. It produces high yield with higher proportion of chip grade tubers. It has early maturity with field resistance to late blight, thus helping farmers in saving on costly fungicides. It is suitable for preparation of Chips owing to its round shape and high dry matter (>20%). It will fill the void of a suitable chipping variety from Karnataka, West Bengal and Madhya Pradesh where processors are in need of variety combining high tuber yield and high level of late blight resistance. Long dormancy and good keeping quality will help storage of this variety for longer period thus ensuring round the year availability of raw material to chipping industry.

MP/4-578: The advanced hybrid is selection from the progeny of cross Kufri Chipsona-1 x MP/92-35. It produces high yield with higher proportion of French fry grade tubers. It has medium maturity with field resistance to late blight and and potato virus Y. It is suitable for preparation of French fries owing to its oblong shape and high dry matter (>20%). Good keeping quality will help storage of this variety for longer period thus ensuring round the year availability of raw material to French fry industry North West and Central plains.

Future Thrusts

Potato has been considered as a serious food security option worldwide and about 15.5% of potato tubers are processed into various products. The potato value addition or processing sectors are well developed in Europe and USA where 30-69% of the total produce is processed into various products. In contrast, India is in developing phase and on its way to have a 'crispy revolution due to emerging growth and rapid progress in potato processing sector. Due to availability of suitable raw material and adoption of improved storage technologies, the potato processing activity both in the organized and unorganized sector has increased from <1% in late nineties to about 7.5% in present scenario. Processing has helped to reduce the post-harvest losses. The reduction in post-harvest losses will not only result in economic gains to the farmers but also provide better food and nutritional security to the country.

Potato products which are fried during the final preparation contain oil or fat and are widely considered to be unhealthy. At least they have the image of unhealthy food because of their fat and energy (calorie) content. This may be encountered to some extent by developing technology for baked chips/fries or with selection of high amylose genotypes which absorb less oil on frying. Acrylamide a toxic and potentially carcinogenic substance that is formed during the Maillard or browning reaction in finish fried French fries and in potato chips needs more emphasis on the breeding goal. Acrylamide is formed from reducing sugars and the amino acid asparagine during heating. Because asparagine is abundantly present in the potato tuber the determining factor for acrylamide formation in potato products is the level of reducing sugars

Analysis of past experience and pattern of Indian processing industry suggests that demand for processing quality potatoes over next 40 years will rise at the fastest pace for French fries (11.6% ACGR) followed by potato flakes/ powder (7.6%) and potato chips (4.5%). The actual demand for processing potatoes will rise from 2.8 million t in 2010 to 25 million t during the year 2050 at an ACGR of 5.61% (Table 4).

Table 4: Raw material demand of potato processing industry (million t)*

Product	2010	ACGRs	2025	2050
Potato chips	2.45	4.5	4.73	14.22
Potato flakes/ powder	0.29	7.6	0.87	5.44
Frozen potato products	0.06	11.6	0.35	5.40
Total	**2.80**	**5.61**	**5.95**	**25.06**

*Source: Singh *et al.* (2014)

To keep the pace with the future needs of growing processing industry in India, suitable cultivars needs to be developed with the desirable traits which are expected are:

1. Varieties with the processing quality demanded by the manufacturers of chips, French fries and flakes. Resistance to low temperature sweetening so that tubers can be stored at 2 to 4°C to control the development of diseases, weight loss and sprouting in store, with reduced reliance on sprout inhibiting chemicals.

2. Varieties with the table/ specialty potatoes demanded by supermarkets. The tubers must be resistant to after-cooking-blackening, attractive skin, good flavour and desirable, low levels of glycoalkaloids and varieties for baking, canning, scooping etc.

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New Approaches in Plant Protection of Potato

Kamlesh Malik and Uma Maheshwari

Address

Potato crop is attacked by a number of pests and diseases that can completely destroy the crop if left unattended. Potato could be a home for many pests which includes insects, nematodes, rats, wild animals etc. In the order of importance, a wide variety of insects can damage potato crops either directly, through feeding on tubers, spoiling the produce and reducing the yields or indirectly by feeding on leaves or stems or transmitting the pathogens which also results in poor yield and quality both. In potato seed production, many need based suitable IPM/IDM programmes are there to control the insects/diseases but they can be different in different geographical areas for e.g. aphids are important in India but Colorado potato beetle is not; nematode problem is being quarantined in Hills and potato wart is restricted to Darjeeling area only.

Sap sucking pests/vectors

Aphids

Green peach aphid (GPA) *Myzus persicae* (Sulzer): *M. persicae* which is known as green peach aphid/peach-potato aphid is most important aphid worldwide. *M. persicae is* highly polyphagous and colonizes hundreds of plants belonging to more than 40 families. This aphid also attacks many ornamental crops such as carnation, chrysanthemum, flowering white cabbage, poinsettia and rose.

Feeding process of aphids: Aphids feed from the phloem of 3 main parts of the plant, stems, leaves, and roots with the stylets of their proboscis. Their stylets are contained within the proboscis when the aphid is not feeding. Stylets could suffer damage while being pushed into the plant phloem as they are very thin. Therefore aphids protects their stylets by secreting a special protective liquid from the tips of their stylets which starts to harden as soon as it leaves the stylets and forms a hard protective sheath around the stylets as they are slowly pushed into phloem tubes Aphids insert their stylets slowly and it takes quite a bit of time to tap into a phloem tube, it can be anywhere from 25

minutes to 24 hours from starting to insert the stylets to actually getting something to eat.

Transmission of viruses: *M. persicae* is a green or slightly reddish aphid which has peach as its primary host and a wide range of secondary hosts including many brassicas. *Myzus persicae* is cosmopolitan in temperate climates. It is highly polymorphic with varying colours from green to red and has complex type of life cycles. Aphids produce both apterous (wingless) and alate(winged) form. Nymph and adults both are equally capable of transmitting viruses.

Flying abilities of aphid GPA: Aphids are weak/passive fliers and in still air they move at about 1.6 to 3.2 km per hour. Their migrations can be quite extensive and they often take advantage of favourable winds to enhance their flight efficiency. Aphids can travel more than 400 km in 9 hours as a result of travelling on low level jet streams. When coming into land from these great heights the aphids home in on leaves reflecting long wave light, they are particularly attracted to the yellowish light emitted from young actively growing crops or older senescing ones.

Monitoring of aphids: Monitoring is must as aphids can disperse and reproduce rapidly anywhere, anytime as and when they found suitable conditions. There is good correlation between these 3 traps. When aphid count is 20 for by visual count then the corresponding figure for water traps and sticky trap would be 9.4 and 3 respectively.

Management

The most important challenge for potato breeder and seed potato grower is to produce seed tuber of high quality as the level of per cent virus infection level has been set up low for seed propagation programmes. It is a well known fact that aphid management is tough as it develops resistance by repeated chemical sprays so the best way is to keep seed material clean by removing unhealthy stocks even showing slight deformation on plant and the combination of mechanical, chemical, cultural control practices may be adopted for the aphid control. Vegetable/mineral oil could be a better option as it inhibits virus acquisition. Monitoring of aphids is important which is done by placing the sticky traps of yellow colour so that the arrival of the winged aphids is known and if big size traps are being used the number would be one trap/900m^2 for monitoring the aphid.

For aphid control the use of mineral oil application is the most favoured tactics when population levels are low. Among insecticides oxydemeton metyl (1.25lit/ha) and imidacloprid (300ml/ha) gave good control.

Aphis gossypii

Aphis gossypii is extremely polyphagous, has 700 host plants world-wide. Among cucurbits, it can be a serious pest on watermelons, cucumbers, and cantaloupes, and to a lesser degree squash and pumpkin and hence the common name "melon aphid." In the south, cotton is an important host, which explains the second common name, "cotton aphid." It is yellow to dusky green in colour and feeds on the underside of leaves, or on growing tips, sucking nutrients from the plant and forms dense colonies on the underside of the leaf. Their feeding also causes a great deal of distortion and leaf curling, hindering photosynthetic capacity of the plant. In addition, they secrete a great deal of honeydew which provides a substrate for growth of sooty mold which affects photosynthetic capacity of foliage.

Management

If insecticides are used to suppress melon aphid, care should be taken to obtain thorough cover of foliage. Leaf distortions caused by aphid feeding provide excellent shelter for the insects, so systemic insecticides are useful. Use of insecticides for other, more damaging insects sometimes leads to outbreaks of melon aphid. The wide host range of melon aphid makes crop rotation a difficult tactic to implement successfully. Also, crops grown down-wind from infested fields are especially susceptible because aphids are weak fliers and tend to be blown about. Infested crops should be destroyed immediately after harvest to prevent excessive dispersal, and it may be possible to destroy overwintering hosts if they are weeds.

It is difficult to disrupt transmission of non-persistent viruses with insecticides, so total dependence on insecticides is not advised. Row covers, whitewash sprays, and reflective mulches or coarse net covers are helpful in delaying or reducing disease transmission, but these are expensive options on large scale. Both aluminum and plastic mulch are reported to be useful for suppression of watermelon mosaic virus. Transmission of non-persistent viruses such as cucumber mosaic virus can sometimes be reduced by coating the foliage with vegetable or mineral oil. Oil is postulated to inhibit virus acquisition and transmission. Oil seems to be most effective when the amount of disease in an area that is available to be transmitted to a crop is at a low level. When disease inoculum or aphid densities are at high levels, oils may be inadequate protection. This can be controlled by same insecticides which are used for *M. persicae*.

Whitefly

Whitefly, ***Bemisia tabaci*** was described over 100 years ago and has since become one of the most important pests worldwide in subtropical and tropical agriculture as well as

in greenhouse production systems. Being highly polyphagous it feeds on large number of plant families. Over 900 host plants have been recorded for *B. tabaci* and it reportedly transmits 111 virus species. The population build up of whitefly is heavy in September and October planted crop in Indo-gangetic plains of India. These plains were identified as seed producing areas of potato because of low aphid periods in winters and that time *Myzus persicae* used to be a major problem in seed production of potato. Both adults and nymphs of whitefly suck the sap from leaves and many tiny adults could be seen on underside of the leaf. Now it has been proven a potential vector of a geminivirus which produces apical leaf curl virus disease in potato. The Geminiviruses/begomoviruses also circulate in the body fluids of whiteflies. It is a known fact that to control/manage whitefly is not easy but a challenge to grow virus free crop. The disease was successfully controlled by controlling the vector population with seed treatment with imidacloprid (0.04%) and first foliar sprays of imidacloprid (0.03%) at 85% germination and second of thiamethoxam (5gm/10lit of water) after 10days of first spray, adult population was also captured on yellow sticky traps.

Leafhoppers

There are several leafhoppers-*Amrasca biguttula biguttula* (Ishida), *Alebroides nigroscutulatus* Distant, *Seriana equata* Singh, *Empoasca solanifolia* Pruthi, *Empoasca kerrimotti* Pruthi *E. fabae* Harris, and *E. punjabensis* Pruthi which damage potato crop. The most important is potato leafhopper *Amrasca b.biguttula* which is polyphagous and phloem/mesophyll feeder. The adults and nymphs are somewhat wedge-shaped with heads that are slightly broader than the rest of their bodies. Nymphs and adults are pale green in colour, have piercing sucking type of mouth parts and can be easily identified as they move back and forth and hence the name hopper. Eggs are laid in the petiole and life cycle is completed in one month. Adults and nymphs both suck the sap from underside of the leaves hence they do the damage by direct feeding. Late instar nymphs are more harmful and feeding results more than twice yield losses compared with similar number of adults. The feeding results in drying of leaves which is known as hopperburn. Symptoms can be easily identified as wedge-shaped (triangular mark of burn) burning from the tip or may be cupping of leaves.

Management

Because of wide host range and highly dispersive nature of potato leafhopper the crop rotation is of very little use. Yield losses can be tremendous if it is not controlled within 30-40 days of planting. In early crop foliar sprays are recommended as the duration of crop is short it is harvested within 60-70 days. Foliar spray with imidacloprid is applied as soon as adult is seen.

Mite

Polyphagotarsonemus latus, commonly known as yellow mite or broad mite is polyphagous in nature. It has been reported on more than 100 plant species. Has very small size can not be seen with naked eyes. With very high fecundity it completes its generation in very short time (approximately 5 days).The injury it produces is often confused with diseases and phytotoxicity. It feeds by sucking the plant sap and inject toxic compounds in tender plant tissues. It usually feeds on lower surface of the leaf and causes leaf edges to become rigid and roll under. The symptoms can be identified by carefully observing the lower surface of the leaf which develop bronze colour. The plant, under heavy attack of mite cease to grow and die. Under heavy attack, losses are more and plant may yield nothing. Control with dicofol @0.2% or spiromesifen 0.04%.

Thrips

Thrips palmi are small insects. Life cycle may be completed in about 20 days at 30°C. When crops mature their suitability for thrips decline. Eggs are deposited egg in leaf tissue and larvae resemble the adults in general body form though they lack wings and are smaller. Larvae feed in groups, particularly along the leaf midrib and veins, and usually on older leaves. Adults are pale yellow or whitish in color, the slender fringed wings are pale. Thrips can be successfully controlled by the chemicals used for other sucking pests.

Root and Tuber Damaging Pests

White grubs

They are polyphagous and cosmopolitan in nature. This was most destructive insect threatening potato production in hilly regions, but now it is becoming a problem in potato producing areas in plains too. In pains, white grub has long been associated with sugarcane crop and now causing the damage to potato crop. Twenty species of white grub have been reported on potato from India. The adult emerges with the first shower of rain in May. The damage is done by second and third instar grub (larval) which feeds on underground part of the plant by making large shallow and circular holes in the tubers The grub stage which can be easily identified creamy white in colour with dark brown head and attains 'C' shape of English letter when disturbed. Tubers infested by grubs have low market value.

Management

1.Deep plowing after harvest of potato is the best way to expose white grubs to high temperature and natural predatory birds. Similar plowing should be done at the time of

planting also. 2. Removal of weeds from bunds around the field will reduce the chances of egg laying as eggs are laid on the grass bunds. 3. Deep placing of seed tuber is recommended. 4. Only well rotten Farm Yard Manure should be applied to the fields as this acts as attractant for grubs to feed on if not fully rotten. 5. Light traps can also be useful to catch the adults as soon as they emerge and kill them in water mixed with kerosene/summer oil. 6. Spray of chlorpyriphos 20 EC (0.1%) immediately after first monsoon showers on weeds and bunds around the field will reduce the number of grubs emerging out of eggs. Spray the crop (ridge portion) with chlorpyriphos 20 EC @ 2.5 l/ ha after earthing-up to kill the larvae.

Cutworm (*Agrotis segetum* and *A. ipsilon*)

Cutworms are polyphagous and most destructive insects. *Agrotis segetum* is commonly found in hills and *A. ipsilon* is common in plains. Peak activity occurs during May-June in Shimla hills, in August in peninsular India and in March April in Bihar and Punjab. In Bihar the tuber damage was 12.7 and in Himachal Pradesh 9.0-16.4% tubers were found to be damaged by cutworm. *Agrotis spinifera* occurs in Punjab, Bihar, Andhra Pradesh and Karnataka. Crop damage is caused by caterpillar (larva) stage only. They cause damage by- (i) young larvae feeding on leaves (ii) mature larvae by cutting the stem of the plant just near the ground and (iii) making irregular holes in the tubers. Smooth, grayish-brown, greasy and plump looking caterpillars are found hiding in the soil near to the stem of the plant during day time. Tuber damage can be from 9.0 to16%.

Management

1. Exposing the larvae to bird predators is the best way. 2. For effective chemical control one should be able to identify the small larvae and the chemical should be sprayed at the appropriate time. The best time is when caterpillars are small and still feeding on the haulms. Once the caterpillar is big enough and moved to the soil, it is difficult to control as older caterpillars are generally less susceptible to insecticides than young caterpillars. Chemical control would be more effective when soil is dry and weather is warm.. For efficient chemical control thorough coverage of foliage with good amount of water is needed. Chlorpyriphos, cypermethrin and triazophos are used to control cutworms on potato.

Potato tuber moth (PTM)

This insect has been causing damage in both potato storage houses and in fields in the country. The damage has been reported from Maharastra, Bihar, Madhya Pradesh, Uttar Pradesh, Kangra valley (Himachal Pradesh), Tamil Nadu, North Eastern hill states and plateau region and Karnataka. The range of infestation can be 30-70% in stored potato. The damage is severe under low rainfall high temperature conditions.

Eggs are laid on underside of the leaf in the field the young larva feed inside the tunnel between two layers of leaf tissue and later on to leaves. The larvae destroy the crop by injuring the leaves and boring into petioles and terminal shoots causing wilting. After tuberization, the eggs are laid in the eyes of tubers through cracked soil or if tubers are exposed. The larvae enter into the tubers and feed on them causing mines. Because of the heat produced by the activity of larvae in the heaps the losses become huge due to tuber rot also. In country store the larvae bore into stored potatoes causing 18-83% tuber damage in NEH hills. Life cycle of PTM is completed in 21-30 days at 27-35°C. Upper and lower threshold temperatures for PTM are 40°Cand 5°C.

Management of potato tuber moth

Physical and cultural: Storage of healthy, uninfested potato tuber is the best way to control potato tuber moth. Cultural practices can contribute significantly to reduce PTM infestation at harvest. Use of healthy seed tubers, Deep planting (10cm) followed by proper earthing-up, lifting of all tubers from field at harvest, destruction of self-grown potato plants would reduce the initial infestation and subsequent population build-up in storage.

Use of botanicals/biopesticides: Covering of potato heaps with 2.5 cm thick layer of chopped dried leaves of Lantana or Eucalyptus can prevent tuber infestation. Use of Granulosis Virus (GV) is extremely effective in reducing PTM damage. Use of sex-pheromones can be made bymass trapping PTM male adults. Chemicals-dusting of the tubers with 5% Malathion or 1.5% quinolphos (125g dust/100 kg potato) will result in good control of PTM but these potatoes should not be consumed.

Termites: The damage done by termite is more in rain fed crops than to frequently irrigated crops. They can be easily identified with brown head and dirty white soft body. These insects are social insects. It is the worker caste of the termite which damages the crops by damaging the roots as a result the leaves of the plant turn yellow and plant starts wilting and ultimately dries as well as making holes in the tubers. The tubers become hollow and filled with soil and that is the typical symptom of termite. The queen lives 5-10 years and lays large number of eggs 70,000-80,000 per day. Best method to control termite is to locate and destroy the termite nest and kill the queen. Crop residues should not be left in the field as they provide food to the termites.

Red ant, *Dorylus orientalis*: They also have a habit of attacking the underground parts of the plant but do not avoid light. They can be seen in large numbers in the field. The ants seen in the fields are workers. Workers of red ant feed on tubers by nibbling and making small but deep circulars holes. The damaged plants wilt in sunlight and eventually dry up. The pest is very difficult to eradicate. Spraying of the crop and drenching of the ridges with chlorpyriphos 20 EC @ 2.5 l/ha

Wireworm: Wireworms are the larvae of various click beetles. The major damage occurs from the time of tuber initiation until harvest and reduces the marketable quality of potatoes. Wireworms bore into the tubers making cylindrical holes and bigger larvae do more damage. The economic threshold is low. The treatment may be initiated if wireworms are detected in a pre-planting soil sample. The presence of wireworms can be monitored by using baits (i) pieces of carrot can be buried in the soil about 7.5 cm deep and 2-3 days later they can be checked for the presence of wireworms (ii) 2-3 tablespoon of coarse whole wheat flour is taken in a small tightly tied nylon netting and if more than one wireworm/m^2 is found then field should be treated before planting or potato should not be planted in that field.

Mole cricket, *Gryllotalpa africana*: This is sporadic in nature and reported from Bengal. Young plants/seedlings are attacked more. The damage can be 5-6% in plants and 10-15% in tubers. Eggs are laid in rainy season deep in the soil, nymphs live underground in branched burrows and feed on roots of cultivated wild plants. They can also damage newly planted seed tubers by tunneling inside. Both nymphs and adults come out in the night and feed on the leaves of the plants.

Leaf eating caterpillars

They are all highly polyphagous and there are few which cause damage to leaves only but cutting and chewing them but few not only feed on leaves but damage tubers too.

Bihar hairy caterpillar, *Spilosoma obliqua* (Walker): This insect is polyphagous and very common in mild winters and spring season. The larva can be identified easily as it has hair all over its body. The newly hatched larvae feed gregariously, in groups skeletonizing the leaves but in later stages as they grow up they feed in segregation completely devouring the leaf, by moving plant to plant and field to field.

Tobacco cutworm, *Spodoptera litura* (Fab.): It is sporadic pest and highly polyphagous. This is widely distributed world over. The caterpillar has the habit of feeding at night and during day time it hides in cracks and crevices. Freshly hatched tiny larvae feed gregariously by scraping the leaves. As they grow they feed singly. The infestation can be very serious if number is more. It has been observed in case of potato that bigger larvae enter the tuber and feed on it if leaves were not available.

Gram pod borer, *Helicoverpa armigera* (Hubner): behaviour is same as above two.

Management of leaf eating caterpillars: These can be managed easily in early instars or when the larvae are small. Alternate host plants can be destroyed where they pass their younger stage and then move to potato crop. Eggs can be located on the underside of the leaves and even tiny larvae could be killed mechnically. To the kill the

pupae, expose them by plowing fields. In severe attack foliar sprays of monocrotophos, quinalphos, chlorpyriphos or malathion is recommended.

Leaf eating beetles, *Epilachna* beetles: Two species are common in India 12 spotted, *Epilachna ocellata* found in higher hills and 28 spotted *E. vigintioctopunctata* common in lower hills. Plant damage is caused by larvae and adults both. Eggs are laid on the lower surface of the leaf which are yellow in colour and easily identified and destroyed. For good control malathion, chlorpyriphos can be applied. Control is easy when larvae are small.

Flea beetle, *Psyllodes plana* Maulik: Adult feed by making small holes on leaves by chewing can be easily identified. The damage starts as soon as plant comes out of the soil. Adults could be identified as they jump immediately if disturbed. Weeds around the fields serve as their protected homes when crop is not there, adult feeds on leaves and larvae on roots of weed plants. They can be controlled by foliar spray of malathion, and chlorpyriphos (2.5 ml/lit of water).

There is no need to spray the crops separately for all these leaf-eating caterpillars as most of them can be controlled by malathion and chlorpyriphos.

Important Diseases of Potato

Late blight, *Phytophthora infestans*

Great famine or Irish Potato famine occurred in Ireland during 1845-1849 and 100000 people died, was the result of late blight *Phytophthora infestans*. The disease occurs in humid regions with the temperatures ranging from 4-29^{0}C, hot and dry weather checks the spread of disease. The famine resulted into the blight-forecasting services/systems were developed by universities and government organizations across the world.

When plant is infected with late blight the lesions appear on the the leaf/petiole or stem. The fungus can be identified as white colored growth of spore producing structures on the margins of the lesions. Tubers can also develop rot which can be severed by the presence of secondary fungi and bacteria (*Erwinia* species). This fungus survives in stores, dump piles, field plants and tomato also is a good host of this fungus. Both sexual oospores and asexual sporangia are dispersed with the wind to newer plants and within few hours they will be infected if temperatures are favourable. At temperature below 15^{0}C the sporangia germinate by producing zoospores (asexual spores with flagella) that encyst and later form the germ tube under certain conditions of temperature and humidity. Above this temperature the sporangia may produce germ tube directly. New sporangia can develop within 4-6 days of infection and blighting of leaves may continue if cool and moist conditions prevail. Oospores have thick walls around them so they

can survive through many seasons. Disease is difficult to eradicate but can be managed with proper use of fungicides.

Management of late blight

Resistant varieties can be used. Many good chemicals are available in the market but timely application is must. Fenamidon based and dimethomorph were found very effective to control late blight. Prophylactic spray of mancozeb (75WP) 0.20% at canopy closure and followed by two more sprays of mancozeb (75WP) 0.20% +dimethomorph (50WP) 0.02% AT 7-10 days interval gave less terminal disease severity and good control of disease.

Early blight

One of the most common diseases of potato and caused by *Alternaria solani* Symptoms occur on stem, foliage and tubers of potato. Initial symptoms on the leaves can be identified as 1-2mm small lesions of brown/black in colour but under conducive conditions this may enlarge and surrounded by yellow halo. Lesions bigger in size (<10 mm) have dark concentric rings and this so-called 'bullseye' type symptom is characteristic of early blight. Lesions keep growing in size and new are also added, leaves become chlorotic and dehisce leading to defoliation. Lesions occurring on stem are often sunken and lens shaped with light colour center and concentric rings. Symptoms on tubers may be identified by the presence of sunken irregular lesions which are surrounded by raised purple boarder. Beneath the lesion surface the tissue becomes leathery/corky and becomes dry later on as a result the tubers shriveled. Early blight infected tubers are dry so less prone to secondary infections by other microorganisms. Warm humid conditions (24-29^{0}C) are favourable for the development of fungus.

Management

Field sanitation as pathogen survives on plant debris. The most effective and cheaper solution includes mancozeb (2-3 gm/lit) and chlorothalonil. They good for tank mix partners but repeated sprays at 7-10 days are required.

Black scruf of potato: It is caused by *Rhizoctonia solani* fungus. On tuber black spots are seen, they look like soil but do not wash away when washed. They are called sclerotia, which are dry tight massaes of fungus mycelium in resting phase. The infection is favoured by cool and moist soil. It can survive on decomposing organic material. Hence one of the best methods is crop rotation to manage this fungus. The planting material should be sclerotia free. Brassica crop are good to clean this fungus as they release glucosinulates in varying amounts which kills the fungus. These chemicals when hydrolyzed release some volatile compounds which are effective against nematodes. It can also cause stem canker in sprouts.

Potato scab: This disease makes the potato unattractive hence the acceptability and market value goes downTubers can be seen with dark brown pithy pathches or warty growth. They are safe to eat, just remove the corky spot/skin/growth and consume the way you want. This is caused by a bacterium like organism, *Streptomyces scabies* that overwinter in soil and fallen leaves.It was first detected in 1882. Wounds are common site for entrance of pathogen.The transmission is through wind, water and infection in the seed.The bacterium can survive in human's digestive tract hence it can also spread through manure. There are many factors responsible for the spread of disease but most common is the acidity of the soil, if pH is more than 5.2 then this soil will make host to more susceptible to scab. It will make host to be more susceptible if soil is light textured and there is abundant organic matter. The depth of the scab can be 1-10 mm.

How to get rid of scab

1. Pick resistant varieties. Buy the seed from reliable source.
2. Another is crop rotation which holds good promise, rotate crop after every 4 years. After potato avoid growing raddish, turnip and beets, grow rye and soybeans as they are less susceptible to scab.
3. Watering will also help, it will help to maintain moisture in the soil. Water is more important in the early stages of crop and this is point when crop is susceptible to the disease.
4. Maintain the soil pH upto 5.8 and if soil is alkaline add elemental sulfur and a fertilizer ammonium sulphate is good which produces acid and raises the acidity of the soil.
5. Use of agricultural gypsum as a soil amendment to reduce the disease can be done. This will help in improving the calcium in the soil which will reduce the attack of the pathogens
6. Limit the use of fertilizers in crop. Even organic fertilizers such as manures will be harmful as it will enhance the growth of bacteria.

Bacterial wilt

One of the most destructive diseases of potato also known as 'brown rot' and attacks more than 200 species of plants such as potato, tomato, egg plant, pepper, peanuts, banana and beans etc. Caused by *Ralstonia solanacearum* earlier known as *Pseudomonas solanacearum,* a soil borne bacteriaum. Based on host plant it attacks it is divided into three races but based on biochemical properties it is divided into 4 biovars. Bacterial wilt is favoured by the temperatures between 25-37^{0}C, this is not a problem where soil

temperatures are below 15^{0}C.Infection is favoured by wetness of the soil. Once the infection has occurred, symptoms will be serious when conditions are hot and dry. Symptoms are wilting of the plant, initially only lower leaves will show the wilting symptoms as shown by shortage of water. Symptoms in tubers are specific, brownish grey area are seen near the point of attachment of the stolon. Cut tubers may show brown ring of vascular tissues.and pus oozing out from this.

Management

Adopt crop rotation with non-solanaceous crops at least for 5 years. Use good quality certified seed. Control alternate hosts. Avoid deep ploughing as organism survives in deep cool layers of soil. Frequent monitoring and inspection of crop.The suspected infected material should not be kept as seed.

Black leg/soft rot: This disease is mainly concern of seed growers as this spreads through seed, soft rot of seed pieces is caused by *Pectobacterium* species. Black to brown discoloration on stem from seed to above ground portion of the stem and as a result stunting and wilting of the affected plant is seen. Key to management is disease free seed.

Brown spot caused by *Alternaria alternaria* considered as weak pathogen.

Potato Cyst Nematodes (PCN) *Globodera rostochinensis* (Woll) (Tylenchida: Heteroderidae)

Economic importance

Globodera rostochinensis popularly called the Golden nematode, is one of the dangerous pests hindering the sustainable production of potato. The ***Globodera pallida*** is another cyst nematode known to infest potato. Its small size, intimate association with their host and amazing adaptation for long term survival in the soil in the absence of a suitable host makes them difficult to control. They are subjected to stringent quarantine and/or regulatory procedures.

In India the potato cyst nematode was first detected in 1961 from a field in Vijayanagaram farm in Ootacamund, The Nilgiris district, also reported from Kodaikanal hills of Tamil Nadu.

Spread of disease

The disease normally spreads by the movement of infested soil, containing cysts and larvae, through the following agencies- (a) Movement of seed potatoes from infested fields to the clean fields (b) Irrigation and rain water (c) Raising and removing of infested

seedling from infested area to clean area (d) Movement of compost from infested area (e) Use of agricultural tools first in the infested area and then in clean plots (f) Through shoes of the workers and hoofs of cattle (g) Through the use of old gunny bags in which the potatoes from infested plots were stored previously.

Host range: Potato, tomato and eggplant are attacked by both species on PCN. The known host range of PCN includes mainly Solanum species and a few species of *Datura, Hyoscyamus, Lycopersicon, Physalis, Physoclaina, Salpiglossis* and *Sarachaall* in the Solanaceae family.

Symptoms and nature of damage: The disease caused by this nematode is often referred to as 'potato sickness'. The presence of the golden nematode in soil is often unnoticed in lightly infested crop which does not show any above ground symptoms at all. Most plants can tolerate nematode invasion and respond by developing more lateral roots as wound response, without affecting their growth and yield.

When the infestation is sufficiently heavy and localized, small patches of poorly growing plants appear in the field, wilting may occur during hot parts of the day. This is often the first evidence above ground presence of the golden nematode. More evenly distributed infestations may cause a sudden failure of crops in whole fields. Repeated cultivation of potatoes encourages the rapid multiplication and build-up of the parasite. Heavily attacked plants remain severely stunted with dull and unhealthy looking foliage. As the season advances, the lower leaves turn yellow and brown and wither, leaving only the young leaves at the top, the entire plant now presenting a somewhat 'tufted head' appearance. The browning and withering of the foliage gradually extends and ultimately causes the premature death of the plant. The root system is poorly developed and the yield and size of the tubers are reduced considerably. Badly infested plants give little or no harvest. Close examination of the roots of infected plants reveal the presence of small pinhead sized, white or yellow female nematodes sticking to the roots.

Life cycle: The hatching of cysts is stimulated by the chemical substances present in the potato root diffusates (PRD) of the host plant. The second stage juvenile (J2) coming out of the cysts moves actively in soil and invade by rupturing the roots with its stylet. The sex of the nematode is determined during J3 stage. The females become sedentary, swollen and remain attached to the roots and posterior part of the body comes out by rupturing the root cells. Males retain their thread shape and come out of the roots to locate and mate the females. The immature females of *G. rostochiensis* are golden yellow in colour while that of *G. pallida* are white/cream in colour. After the female dies, the body wall thickens to form a hard brown cyst that is resistant to adverse weather conditions. Each cyst contains 200-500 eggs and is easily dislodged in soil at harvest. The cysts can survive in soil for 20-30 years even in the absence of a suitable host crop.

Management of PCN in India: It remains a serious endemic pest of potato in The Nilgiris region due to intensive cultivation of potato and favourable climatic conditions.

Resistant varieties: In India, the breeding for PCN resistance uses mostly sources from *S. vernei*. The first cyst nematode resistant cultivar, Kufri Swarna was released in 1985. Recently, another *S. vernei* derived resistant hybrid 'OS/93-D-204' has been selected and released as a variety 'Kufri Neelima' for Nilgiri hills.

Chemical control: The use of systemic insecticides, application of Furadon 3G at 2 kg a.i./ha at the time of planting is being recommended as a part of package of practices for potato in the Nilgiris to bring down the PCN population. However, repeated use of nematicides is not only expensive but also hazardous to environment.

Cultural control

Crop rotation: Crop rotation with non-solanaceous crops is widely recommended for management of PCN. A three to four year rotation with crops like radish, cabbage, cauliflower, turnip, garlic, carrot, green manure crop like lupin etc. brings down the cyst population by more than 50 per cent.

Trap cropping: Trap cropping with susceptible potato (Kufri Jyoti) attracted more juveniles and recorded more reduction in cyst population (31%) than the resistant potato, Kufri Swarna (22%). The trap crops were destroyed before the completion of PCN life cycle in 45 DAP.

Physical control: Trapping of heat in soil from solar radiation by solarization increased the soil temperature up to 44^0C in top 5cm and up to 40^0C in 5-10 cm. This resulted in decrease in PCN population and increase in potato yield.

While using chemical pesticide one must be very careful and must know the harmful effects of chemicals on plants as well as on human life so that maximum benefit can be achieved without harming the ecosystem.

Potential of *Allium* species as Leafy Greens

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There are more than 1000 *Allium* species grown in various parts of the world and new species are being discovered every year. Onion and garlic are the major *Allium* vegetables and the bulbs of these vegetables are included in everyday diet mostly as spice. Over the past few years, there has been a gradual shift in consumption pattern. Numerous new vegetables are included in diet and people are exploring other vegetables which were either exotic or localized to certain places. Emphasis is given to include vegetables having high antioxidant capacity and other health benefits. Apart from the use as spice, onion and garlic and other *Allium* vegetables have good potential to be included in our daily diet as leafy greens. *Allium* vegetables are characterized by presence of numerous health benefitting chemicals, especially organosulfar compounds, flavonoids and saponins.

Numbers of *Allium* vegetables are valued as leafy greens in different parts of world. The *Alliums* which have potential to be included as leafy greens in sub-tropical climate of Delhi and other similar climatic condition are discussed.

Bunching onion (*Allium fistulosum*)

This is also known as Japanese bunching onion, Welsh onion and has high demand in Japan, China and Korea. In India, it is used in hilly regions of Northern and North Eastern India.

Nutritional importance: Bunching onions are very low in calories (31 calories/100g), good source of fibre (2.6 g/100 g), vitamin A (997 IU/100 g), vitamin K, B complex and minerals like copper, iron, manganese, and calcium.

Pusa Soumya is a recently notified variety of bunching onion. In the extreme climatic condition of Delhi where temperature goes as high as 45°C during hot summer months and around 2-3 °C during peak winter season the crop remain green and marketable. The variety is free from major pests and diseases, therefore, consumers can enjoy pesticide free product. It is easy to grow, require less input and care and fetches premium price

during April-September, when there is scarcity of leafy greens in the market. It can be harvested and used round the year and have high demand in city hotels as an ingredient for *vegetable biriyani* and other exotic cuisines.

Economics: A survey at Azadpur Vegetable Market, Delhi revealed that bunching onion sells at Rs120-150/Kg during May - June. In retail market, it is sold at Rs. 40-50/250 g. Considering the yield at 20 tons/ha, and sell price of Rs 100/kg, the gross return will be Rs 45,000 from an area of 250 m^2 in 4-5 months crop.

Production Technology

Method of propagation: Seeds and division of clumps.

Season: Nursery sowing is done in November. It can be planted round the year except hot summer months through division of clumps with adequate provision of irrigation. There should not be water logging in the field.

Spacing: 8- 10 cm × 10- 12 cm.

Method of planting: Preferably planted on ridges, however, flat bed planting can also be done.

Nutrition: 20-25 t/ha well decomposed FYM and 150 kg N, 80 kg P_2O_5 and 120 kg K_2O/ha. Two split application of nitrogenous fertilizer at 40 and 60 days after transplanting is recommended.

Weed management: After transplanting, apply Oxyflurofen 23.5% EC @1.5-2.0 ml/L or Pendimethalin 30%EC @ 3-4 ml/L followed by flood irrigation. Thereafter, need based hand weeding and hoeing is done.

Nipping of the apical bud: The apical bud is removed at early growth stage to promote shoot growth and improves yield by 10-20%.

Blanching: In South -East countries where bunching onion has high demand, mostly the underground stalk is consumed. To increase the stalk length, blanching is practiced. Blanching is done by covering the lower portion of the plants with soil (earthing up) as the plants grow.

Plant protection: The variety is free from major pests and diseases. Therefore, consumers get pesticide free products. Field sanitation should be ensured.

Harvesting: The crops become ready for harvesting 45-50 days after transplanting. If they are left in the same place, harvesting can be done round the year. From an established

crop, side shoots are uprooted and marketed. After harvesting, the soils around root zone should be removed.

Sorting and Grading: The outer dry leaves are removed and the produce is graded into different grades based on leaf length and thickness of the stalk for easy marketing. The leaves are bunched in 6-8 plants/bunch and sold.

Packaging: Shrink wrap-packaging is recommended to keep the produce fresh, attractive for longer periods of time and for super markets.

Green Onion (*Allium cepa*)

Green onions are in high demand from October to March and the period coincides with Dussehra to Holi period. Green onions are the common onion varieties with foliage and under developed bulb. Earlier white bulbs varieties were preferred but now-days red/ dark red varieties are also preferred due to increased consciousness among consumers regarding health benefits. Almost all the short day onion varieties can be grown for green onion production. Varieties with greater number and longer leaf lengths and early bulking are preferred for green onion production.

Production Technology

Varieties: Pusa White Round, Pusa White Flat, Pusa Shobha, Pusa Sona, Pusa Red, Pusa Madhavi, Pusa Riddhi, N-53, Agrifound Dark Red, Bhima Dark Red, Bhima Super etc.

Growing Methods: There are two different methods of growing green onion.

1. Sets
2. Seedling transplanting

Sets:

In Northern part of India, particularly in adjoining areas of Delhi, the uncertain climate during July (delayed rain/ excess rain and high temperature) results in heavy mortality of onion seedling and seedling take more time to recover from transplanting shock and bulking (bulbing is delayed by last week of October). In such cases, set method of growing is recommended to have higher yield and better return.

Nursery raising for set production:

Seeds are sown in nursery during February first fortnight on raised bed of 1-1.2 m wide and length as per convenience. Seeds are sown in lines after treating with Bavistin

@ 2 g/Kg of seed. After sowing, mulches of dry grasses are spread over the bed for conservation of moisture. The seedbeds are lightly irrigated in the evening based on soil moisture condition. Seed germination starts in 7-10 days and as soon as seedlings emerge, the mulch materials are removed. After removal of mulches, seed beds are drenched with Ridomil @2 ml/L. Once the seedlings are 2-3 leaf stage (10-12 cm), hoeing is done. Need based irrigations are provided and the nurseries are kept weed free. 3-4 hoeings are done till last week of April or first fortnight of May. The top leaves dries during last week of April or first fortnight of May and they are uprooted and stored in ambient condition.

Seedling transplanting: *Kharif* onion varieties like Agrifound Dark Red, N-53, Bhima Dark Red, Bhima Super and other varieties like Pusa White Round, Pusa White Flat are preferred.

Sowing time: Seed sowing is done in July. Sowing is done in lines 5 cm apart in raised nursery bed after treating seeds with Thiram @2g/Kg seed. Nursery is covered with green shade net to protect from high temperature. Regular care is taken in the nursery as mentioned above. The shade nets are removed in the evening and again covered around 8-9 am. As soon as monsoon arrives or temperature drops to around 35 °C, shade net is removed; otherwise, sunlight deficiency results in lanky seedlings. The seedlings become ready for transplanting in 40-45 days (by).

Method of planting: Raised bed method is followed. Bed width is kept 90 cm and 8 rows are planted in a bed.

Time of planting: Sets are planted in during second fortnight of July or first week of August. The sets may be dipped in Rootex before planting for early root development of plants. Seedlings are transplanted during last week of August or early week of September. The seedlings are dipped in Ridomil @2ml/L for 30 minutes before transplanting.

Spacing: 8-10 cm × 10-12 cm.

Nutrition: 15-20 tons FYM, 120:50:50:50:50 kg NPK and S are applied.

Weed management: Pendimethalin 30 EC @3.5-4.0 ml/l after transplanting and need based hand weeding after words. 2-3 hoeing improves crop growth.

Water management: Drip irrigation is the best method. Irrigation is provided based on soil moisture condition.

Plant growth regulators: Foliar spray of GA3 @ 60 ppm or salicylic asid @250 ppm or lihocin @2500 ppm 30 days after transplanting improves number of leaves per plant.

Plant protection: For control of fungal foliar disease, hexaconzole @0.1%, mancozeb @0.25%, tricyclazole @0.1% or propioconazole @0.1 % at 15 -20 days interval from 30 days after planting or as soon as disease symptom appear in the field is sprayed. For control of thrips 0.2% carbosulfan or 0.1% fipronil or 0.1% profenofos is sprayed. Mite is effectively controlled by spraying of dicofol (0.2%) or sulphur (0.05%). Stickers should be incorporated for better efficacy of the plant protection chemical. No chemicals should be sprayed 15 days before harvest.

Harvesting: The plants are uprooted with gentle pool. Soil adhered to root and bulbs are thoroughly cleaned before marketing.

Sorting and Grading: Diseased and dried leaves are removed. Grading is done based on leaf length and bulb size.

Packaging: Shrink-wrap packaging is recommended.

Green garlic (*Allium sativum*)

Similar to green onion, green garlic are the leafy parts of garlic along with small undifferentiated bulbs. They are also in demand and fetches better market price during October to February. They are used in making chutney, soups, mixed vegetables and other dishes.

Production Technology

Varieties: There are no specific varieties developed for green garlic production. Varieties with higher foliage are preferred. Bhima Omkar, Bhima Purple, G-1, G-41, G-50, G-189, Phule Baswant can be planted for this purpose.

Clove treatment: Sprouting and early vegetative growth is temperature dependent. The cloves may be kept in cold chamber for 15-20 days before planting. Cold treatment facilitates early sprouting. The cloves should be dipped in rootex before planting. It helps in early root development and establishment of the crop.

Time of planting: The sprouted cloves should be planted during September on raised beds.

Method of planting: Cloves are planted on raised beds at 10 cm apart. The bed width is kept 90 cm and 8 rows are planted in a bed. The pointed part of cloves should be planted in upright condition.

Protection from high temperature: Garlic favors cool climate for growth and leaf development. A day temperature of 13-24 °C and night temperature of 8-20 °C is ideal for

good growth of the crop. The area should be provided with green shade net during initial stages of crop growth and establishment.

Nutrition: 20-25 tons FYM, 80:40:40:40, NPK and S. Foliar application of 1% urea promotes vegetative growth.

Irrigation: Drip method is most suitable. Irrigation should be given thoroughly during initial stages of crop growth and establishment as it helps in maintaining comparatively low temperature.

Weed management: After planting cloves, pendimethalin 30 EC @ 3.5-4.0 ml/L is given, followed by flood irrigation. Dubsequently need based weeding and hoeing is done.

Plant growth regulators: Spray of lihocin @2500 ppm or salicylic acid @250 ppm or vermiwas@5% improves number of leaves.

Plant protection: If symptoms of fungal disease are noticed on leaves, spray hexaconzole @0.1%, mancozeb @0.25%, tricyclazole @0.1% or propioconazole @0.1 % along with stickers. For contro

]l of mites, spray dicofol (0.2%) or sulphur (0.05%). Thrips is controlled by spraying of 0.2% carbosulfan, 0.1% fipronil or 0.1% profenofos. There should be no chemical spray for the last 15 days before harvesting the crop.

Harvesting and post harvest handling: Harvesting is preferably done in the early morning hours. Light irrigation is given prior to harvesting and soil around roots is cleaned thoroughly before marketing. Diseased and dried leaves are removed. Grading is done based on leaf length.

Packaging: Shrink-wrap packaging is recommended for super market.

Leek (*Allium porrum*)

It is another member of *Allium* vegetable which can be successfully cultivated in climatic condition of Delhi and similar climatic conditions. It is popular in European and USA markets. The underground portion is blanched and used in soups, sliced, used in garnishing and other preparations. The tender plants can be used as leafy greens before the leaves become too fibrous. The tender leaves along with blanched lower parts can be marketed during December to February while the blanched underground portion can be used round the year.

Nutritional importance: Leeks are good source of vitamin A (1667 IU/100 g), vitamin C (12 mg/100 g), vitamin K (47 mg/100g), folate (64 μg/100), iron (210 mg/100 g) and

zinc (1.2 mg/100g) and 100 g serving meets 55%, 20%, 39%, 16%, 26% and 11% recommended dietary allowance. They contain significant amount of fibre (1.8 g/100g) and low in calories (61 Kcal/100g).

Production Technology

Variety: London Flag and American Flag are two popular varieties.

Season of growing: Nursery sowing is done during November.

Seed rate: 5- 7 kg/ha.

Seed treatment: Seeds are treated with Bavistin @2g/kg seed before sowing.

Nursery Preparation: Seeds are sown in raised nursery beds. Nursery sowing and managements are similar to onion.

Transplanting: Seedlings are transplanted in 15 cm deep furrows to facilitate earthing up operation.

Spacing: 10-15 cm × 25-40 cm.

Nutrition: 25-20 tons well decomposed FYM/ha, 80-100 kg N, 60 kg P and 80 kg K/ha.

Water management: Uniform irrigation is recommended for good growth of the crop. 12-15 acre-inches water is required. Sandy-loam soils require frequent light irrigation.

Blanching: As the plants grow, furrows are filled and rows are made. During filling the furrows, care should be taken so that soil does not reach between the leaves.

Weed management: Pe-emergence application of Pendimethalin 30 EC @3.5-4.0 ml/lt and subsequent need based irrigation is recommended.

Plant growth regulators: NAA @50 ppm or ethephon 50 mg/l 30-45 days after planting.

Plant protection chemicals: Leeks are comparatively disease free than onion and garlic. However, if there is symptom of disease development or pests infestation, similar control measures like onion is taken.

Harvesting and post harvest handling: Before harvest, light irrigation is given. Harvesting is preferably done in the early morning hours. Whole plants are uprooted and cleaned before marketing. Dried outer leaves are removed and they are graded based on leaf length and stalk thickness.

Packaging: Shrink-wrap packaging is recommended to increase consumer appeal and for super market sale.

Garlic Chive (*Allium tuberosum*)

This is another member of *Allium*, which can be grown in Delhi condition. The leaves are valued for garnishing, preparing chutneys, soups and posses therapeutic properties. This species haves winter dormancy and leaves are available from February to November. Studies at our centre revealed that leaves have high antioxidant capacity. It can be propagated both by seeds and division of clumps.

Now-a-days *Allium* species are gaining popularity among the consumer. Earlier onion and garlic were only considered important *Allium* species but today these allied species are also gaining popularity particularly as leafy greens. Being leafy, they are good source of carotene, vitamin C and fibre. They provide excellent opportunity for crop diversification both for growers and consumers. They are sort of exotic and under-utilized and fetches better market price, provides economic boon to the farmers. Most of the allied species are easy to grow and least affected by disease and pests and consumers get the benefit of pesticide free products. They are best suited to kitchen gardens to provide year round healthy leafy green. They are used fresh, cooked or processed. Different species have different habitats and here we discussed only few species which can be grown successfully in similar climatic condition of Delhi and effort is on to study the adaptability of other *Allium* species under Delhi condition so that more members of *Alliums* can be included as leafy greens.

Hybrid Seed Production in Onion (*Allium cepa* L.)

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Onion, a member of *Amaryllidaceae* family, is one of the most important vegetable crop grown throughout the world for its value as vegetable, spice and medicinal food. On worldwide basis, India occupies 19% of the gross cultivated area and produces 17% of the total production. And among 142 onion growing countries, India stands at 88th position in terms of productivity (16.1 t/ha) compared to the highest productivity countries viz., Republic of Korea (66.5 t/ha), Austria (64.1 t/ha), USA (55.9 t/ha) etc. Primary reason for low productivity is that Indian onion is cultivated under short day tropical conditions where limitation of cultivation period (90-130 days) and susceptibility to insect pests and diseases due to high temperature and high humidity exists. Secondary reason is the use of farmer's own seeds and/or seeds of open pollinated varieties (OPVs) where there is no guarantee of uniformity in terms of size, shape, colour, maturity and resistance to biotic and abiotic stresses. This situation can be ameliorated by growing hybrids since hybrids are superior than OPVs in terms of yield and other horticultural traits. Market share of onion hybrids is over 95% in countries like USA, UK, Germany, Italy whereas in India it is less than 5%. Main limiting factors for onion hybrid development in India is the unavailability of inbreds. Biennial flowering habit slows the inbreeding process and it takes 10-12 years for inbred development. Moreover, severe inbreeding depression also makes inbred less vigorous with more mortality. Over the last 60 years of onion breeding, more than fifty OPVs have been released from public sector but not a single hybrid has been released at national level.

In onion, two types of male sterility systems, CMS-S (Jones and Emsweller 1936) and CMS-T (Berninger 1965), have been utilized for F1 hybrid cultivars. A single restorer-of fertility locus (Ms) is involved in fertility restoration of the CMS-S system (Jones and Clarke 1943) whereas three independent loci are known to control fertility restoration of male sterility caused by the CMS-T cytoplasm (Schweisguth 1973). In addition, some undefined cytoplasm types have been reported (Berninger 1965; Pathak and Gowda

1993; Havey 2000). Of the two CMS systems in onion, CMS-S is more widely used for hybrid cultivars because of its stability in diverse environments (Havey 2000).

In application of the CMS-S system, male-sterile lines (Smsms) are propagated by crossing with a maintainer line (Nmsms) that contains normal (N) cytoplasm and a homozygous recessive genotype at the Ms locus (msms). Therefore, it is important to identify the cytoplasm (S or N type) and the alleles of the restorer-of-fertility locus (MsMs, Msms, msms) in breeding maintainer lines. However, the extraction of maintainer individuals from onion populations is difficult and time consuming because of the biennial generation time, the high frequency of the dominant allele at the Ms locus (Havey and Randle 1996) and prevalence of the S cytoplasm (Havey 1993). Molecular marker-assisted selection (MAS) is a powerful tool that facilitates the rapid transfer of economically important agricultural genes (e.g., genes for disease resistance, high-quality characteristics, male sterility, and fertility restoration into cultivars (Havey 1995).

In the Indian context, more than 60 commercial open pollinated varieties suited to different zones of India have been released through different research centres and State Agricultural Universities but till date not a single onion hybrid has been released on the national level. Sen and Srivastava (1957) were the first to attempt developing F_1 hybrids in onion as early as in 1948 using exotic male sterile lines with Indian local male stocks and first hybrid 'VL 67' was released for Uttarakhand (Hills) in 1973 (VPKAS, 2015). Subsequently, male sterile plants were also isolated from indigenous germplasm by Patil et al. (1973) in cultivar 'Niphad-2-4-1', Pathak et al. (1980) in 'Nasik White Globe' (IIHR-20) and in Pusa Red (DARE, 1986). Two hybrids, Arka Kirthiman and Arka Lalima were released by IIHR, Bengaluru but somehow they did not gain attention of the farmers and were not released at the national level to the farmers.

Hybrid Seed Production in Onion

Floral biology and pollination behaviour: Floral structure of onion is called umbel and is composed of a bunch of 200-600 small flowers, each of which opens in a definite orders causing flowering to be irregular and lasts for 2 or more weeks. Each individual flower contains 6 stamens, 3 carpels united into one pistil and 6 perianth segments. Flowers are protandrous in nature and dehiscence takes place 3-4 days prior to stigma receptivity. Honey bees, syrphid flies, bumblebees and butterflies are the main pollinating agent.

Selfing and Crossing:

Selfing: Selfing in onion is done only on limited scale as it becomes difficult to maintain the inbred lines beyond S2 generations due to drastic inbreeding depression. Selfing

is done by putting individual cages over the plants. Flies are generally used to ensure pollination within cages. Sometimes it is convenient to enclose 2-3 umbels of the same plant in a muslin cloth bag before anthesis. After anthesis, the umbels are rubbed against each other daily for a few days to ensure self pollination.

Crossing: As soon as few buds in an umbel open, the whole umbel of the female parent is bagged in a muslin cloth bag or butter paper bag. Flowers are removed daily for a few days until the peak flowering has reached after which buds are emasculated as they open and when sufficient buds have been emasculated the remaining young flower buds are removed. Umbel of pollen parent covered by a muslin cloth bag is cut off and its stalk placed in a glass bottle filled with water. This bottle is fastened to a bamboo/wooden stake and fixed in soil close to the female parent. Female parent umbel (emasculated one) and the pollen parent umbel are now enclosed in the same common bag. For a few days in the morning, the male umbel is gently rubbed over the emasculated umbel to ensure pollen shedding and cross pollination. A few common houseflies can also be introduced into the bag for pollen transfer.

Technique of hybrid seed production in onion:

Cytoplasmic genic male sterility has been commercially exploited for hybrid seed productions of onion. Three parental lines namely A, B and C are used for hybrid seed production.

A line: It is the male sterile line (female parent) having genetic constitution S*msms*, which produces the F1 seed.

B line: It is the maintainer line i.e. male fertile counterpart for maintenance of male sterile line A, having genetic constitution N*msms*.

C line: It is fertile pollen parent or inbred which is genetically diverse from A and B lines having genotypic constitution N*MsMs* or N*Msms* or S*MsMs* or S*Msms*.

The lines A and B are genetically identical except that the former is male sterile and the latter is male fertile. The male sterile line A is maintained by crossing with line B whereas hybrid seed production is done by crossing line A with line C .

Maintenance and multiplication of A, B and C lines under controlled condition

Multiplication of A, B and C lines is done under insect proof cages. A and B lines are planted alternatively in the same cage for multiplication of A line while C lines is planted separately in another cage. A plastic or wire net cage of 20 x 20 or 24 x 24 mesh, measuring 6m x 3m x 2m with a small door at one corner is suitable for

this purpose. The above size cage can accommodate four rows of bulbs spaced 60 cm apart to produce 1.5 - 2.0 kg seeds. Cage is put over the plants before flowering and precaution should be taken to avoid touching of umbels to the upper surface of cage as this would cause the stigmas to protrude and get contaminated with foreign pollen. A bee hive containing the medium sized colony is put inside the cage 4-5 days before the commencement of flowering. It is very much essential to rogue out the pollen bearing plants from A line and pollen sterile plants from B line every morning before the anther dehiscence. Other off-types occurring in A and B lines should also be rogued out. C line or restorer line can be multiplied separately in the same way as mentioned above.

Large scale multiplication of A, B and C lines under open conditions:

For planting large areas of commercial crop it will be necessary to increase the seeds of the A, B and C lines in open. Stock seed of A line can be produced by planting A and B lines in an alternate rows in a large plot of 0.40 hectare (1 acre) or more with several rows of B line planted around the periphery of the field to prevent contamination. Seed production plot should be 1.5 km away from other onion seed crop and roguing of the off-types plants should be done in the same way as in the cage. Seeds of C lines can be multiplied separately under open condition in the similar manner. Bee hives, purchased from commercial apiaries, can be kept in between the seed filed to improve pollination and hence seed set also.

Production of F1 hybrid seed

Commercial hybrid onion production under open condition can be done in an isolated field. Bulbs of A (male sterile) and C (pollen parent) lines are planted alternately in the ratio 4:1 or 8:2. Planting of the two lines is adjusted in a such a way that there is synchronization of flowering in both the lines. In large field, it is essential to keep about 3-4 bee hives per acre to ensure effective pollination by honey bees. It is very essential to rogue out pollen bearing plants and other off types from A line in the morning before the anther dehiscence. At the time of harvesting, care should be taken to avoid mixing of the seeds of A and C lines. If the seeds of C lines are not to be saved, its flower stalks may be cut and destroyed as soon as possible after the pollination. Seeds collected from rows of A line are the hybrid seed.

Seed harvesting: Seed stalks become ready for harvesting 4-5 months after transplanting or bulb planting. For bulb to seed production method, as the number of flowering stalks are more and they do not mature in the same time, therefore, 2-3 harvesting need to be done. Seed stalks are harvested leaving 2-3 cm below the umbel

and allowed to dry properly. The seeds are threshed and dried to a moisture content of 6-8%.

Seed standard: Seed quality is estimated by various parameters and the germination should be 70%, purity 98% and inert matter 2% for both foundation and certified seed. Other crop seed and weed seed should not be more than 5 counts/kg for foundation seed and 10 counts/kg for certified seed. Seeds are packed at 8% moisture content in ordinary packs and at 6% moisture content in vapour proof packs.

Crop care:

Planting Spacing : Row to row spacing of 45 cm and bulb to bulb planting at 30 cm is sufficient for good seed production. In case, onion seed production is done under drip irrigation a spacing of 60 cm x 20 cm is preferred.

Irrigation Methods: Both surface and drip irrigation can be used. It has been found that in surface irrigation 90 ha. cm quantity of water is needed whereas under drip irrigation only 67.5 ha. cm is required which amounts to 33% saving of water. Sprinkler irrigation cannot be used as it affects pollination.

Fertilizers: N, P and K are applied at 1:2:2 ratio during seed bed preparation. At the main field, higher level of nitrogenous fertilizer increases seed yield at the cost of quality. High level of potash fertilizer has been reported to increase seed quality. Ideal nutrition requirement depends on soil type, available nutrient status of the soil and removal of nutrients by crop. FYM @ 25 tons/ha followed by NPK @ 100:50:50 kg/ha can be applied. First 50:50:50 kg/ha NPK is given at the time of bulb planting whereas remaining N should be given in 2 splits (30 days and 45-60 days after planting). 1% spray of Polyfeed (19:19:19, NPK) at 30 & 60 DAP and one spray of multi K (0:0:50) after 60 days of planting can give good results.

Water management: There should be adequate moisture in the soil during seed stalk formation and maturity. Water stress during these periods adversely affect seed yield. Towards the end of seed maturity, irrigation should be avoided and rain during this time adversely affects seed quality.

Weed management: Onion is heavily infested by weeds. Spray of Pendimethalin @2-2.5ml/l or Goal @ 1.5-2.0 ml/l after planting of bulbs and one hand weeding after 45 to 60 day after planting should be done

Drying and Threshing : Harvested umbels should be dried under open sun and threshing of seed can be done by rolling, threshing machine or combines. The seed should be dried in open sun till 6 to 7 per cent moisture level is attained.

Average Seed yield : Seed yield varies between 5-7 q/ha.

Seed packing: Seeds should be packed in 400 gauge poly bags for maximum viability and storage for a long time.

Storage of seed: Seeds can be stored at 30 – 35°C for 15–18 months and under cold Storage at 15°C with 30–40% RH for 3-4 Years.

Plant protection: A wide variety of pests and pathogens attack onion in different growing season and cause substantial losses if they are not controlled at initial stages. The major problems are:

Diseases:

Purple blotch (*Alternaria porri*): Favourable conditions for this disease are 28-30°C temperature and 70-90% relative humidity. Symptoms include small, sunken, whitish flecks with purple coloured centres on leaves and flowering stalk. Lesions spread forming dead patches and ultimately leaves and stalk fall down from the point of attack. Summer ploughing and exposing the soil reduces the intensity of the disease. Application of Propiconazole, Tricyclazole or hexaconazole, Dithane M-45 or Ridomil 0.2% along with some sticker as soon as the spots appear in the plant, effectively control disease development and spread.

Stemphylium blight (*Stemphylium vesicarium*) : The disease intensity is more in seed crop (20-90%) than in the bulb crop (5-40%). Symptoms appear as small yellow to orange spots or streaks on one side in the middle of leaves or flower stalks. Application of propiconazole, hexaconazole, tricyclazole @0.2% along with sticker can control the disease.

Black mould (*Aspergillus spp*) : This is a major storage disease. Black mould appears between scales, which can be seen with the naked eye. Bulb rotting takes place and to avoid this, bulb injury during harvesting should be avoided, and bulbs showing black spores should be removed periodically and proper sanitation measures should be adopted in the storage and the storage temperature should be kept around 15-20°C.

Other diseases which appear in onion nursery and field cultivation are Damping off, Colletrichum blight, Fusarium basal rot, downy mildew and bacterial rots are common.

Pests:

Thrips (*Thrips tabaci*): This is a major pest of onion and leaves infested with thrips develop spotted appearance which turn into pale white blotches - a condition known as

'silvertop'. The losses have been estimated to be as high as 50% and seed production and seed viability is also hampered due to thrips attack. Adoption of crop rotation, barrier cropping and use of resistant varieties are effective in controlling thrips. Spray the crop with Profenofos @ 1-2 ml/l of water or Carbosulfan @ I ml/l water + Sticker @ 5 ml/l of water at fortnightly interval. Introduce barrier cropping (2 rows of maize or outer row of maize and inner row of wheat) for thrips management

Onion maggot (*Hylemia antiqua*) : Maggots enter the bulb through roots and attack the tender portions. The infested plants turn yellowish brown and finally dry up. During storage the affected bulbs get infected by secondary pathogenic organisms and rot. Adoption of crop rotation is beneficial. This is a disease most in organically grown onion.

Virues : Onion bulb crop and seed crop is affected by many viruses and out of the Onion Yellow Dwarf Virus (OYDV) and Iris Yellow Spot Virus (IYSV) are becoming more common and devastating.

Quality Seeds Production of Onion and Garlic: Challenges and Opportunities

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Onion (*Allium cepa* L.) and garlic (*Allium sativum* L.) are major bulbous crop among the cultivated vegetable crops.An Indian culinary preparation is incomplete without onion and garlic. They are valued for its anticarcinogenic activity, antioxidant, antiasthmatic, immunomodulating and antimicrobial property (Elberry *et al.*, 2014). The important onion producing countries in the world are China, India, Bangladesh, Egypt and Korea whereas China, India, Egypt, USA and Iran are the major garlic producers in the world. In India onion and garlic are grown in an area of 1.19 million ha and 0.26 million ha respectively (FAO, 2016). The major onion producing states are Maharashtra, Madhya Pradesh, Karnataka, Gujarat and Bihar which occupy 73.17 % area and contribute 71.54 % towards production. Whereas Rajasthan, Madhya Pradesh, Uttar Pradesh, Gujarat and Punjab are the major garlic producing states which occupy 78.60 % area and contributes 87.86 % towards production (Anon, 2017). The productivity of onion and garlic is 17.18 t/ ha and 5.28 t /ha, respectively (Anon, 2017) and stands at 90th and 72nd in onion and garlic productivity. The Republic of Korea tops the productivity (65.27 t/ha) in onion and Uzbekistan (36.43 t/ha) in garlic in the world. Low yielding short day genotypes, susceptibility of all available genotypes to major pests and diseases and improper or inadequate use of production technologies, limited availability of quality seeds of high yielding varieties and low seed replacement are some of the reasons for low productivity in India (Gopal, J 2015). Besides meeting the domestic requirement, India has exported 34.92 lakh tonnes of onion worth Rs. 4651.72 crores during 2016-17 (DGCIS, 2017).

Seed quality depends on many factors, such as: environmental conditions during growth of mother plant and seed development, province, location of seeds on the plant, time and technology of seed harvesting, storage conditions and methods of pre-sowing seed treatment (George, 1987), bulb size;Yalamalle, 2016), spacing (Kumar *et al*. 2015), nutrients (Kumar *et al*. 2018), pre planting treatments (Ami *et al*. 2013, Khokhar, 2009), flower regulation (Yalamalle and Tomar 2018) and seed health (Caviness 1994).

Quality Seed Production of onion

Formal sector which includes the government agencies and private seed companies meet only 18-20 % of the total seeds requirement of the country and 80 % of the seed is produced by the farmers themselves, who dominantly use old and obsolete cultivars. Which are often produced without meeting the isolation standards resulting in poor quality seeds (Gopal Jai, 2014). Traditionally commercial onion seed production is taken up in the state of Maharashtra. Which is the primary producer of onion seed in India. Any loss of crop due to biotic or abiotic stress may lead to shortage of onion seed in India and may lead to reduction under cultivation in onion. Often due to intensive cultivation and unscientific seed production programmes, there is problem of getting isolated field for seed production due to which large quantity of farmers produced seed in genetically impure. Thus seed production in newer areas can play an important role in augmenting the quality seed supply.

Potential areas for seed production

In India, the short day types of onion is cultivated on large scale in the northern plains, central and southern part of the country expect higher hills where the long day types onion varieties like Brown Spanish and Yellow Spanish etc.are grown over a limited area. Therefore, the seed production of the short day types of onion is done in central part of the country particularly in Mandore and Khandawa region of MP, Nasik and Pune of MS and Rajkot district of Gujarat. North Indian states like Madhya Pradesh, Rajasthan, Haryana and Uttar Pradesh have 20 % of the area under onion cultivation and contribute 25 % to the total onion production in the country (NHRDF, 2014). These regions have high potential to become seed supplier to the nation. Cooler climatic conditions during November to February are not only congenial for bolting and minimal thrip incidence, which is major insect pest of onion seed crop but also vector for various viruses like IYSV, OYDV, GCLV etc. (Jones and Mann 1994). Northern state are not lower seed yield, but there is a potential for seed production in north under delayed planting and proper management of diseases.

Optimized planting time for quality seed production under Northern plains

Flowering and seed set in onion depends on photo thermo cues from the environment (Jones and Mann 1963). The early planting of bulbs leads to poor vernalization and seed set and late planting results in heavy losses due to heavy incidences of disease, viz. stemphylium blight, purple blotch. The planting time must also take into account the synchrony between the flowering and pollinator activity. The time of planting has great impact over the seed yield and incidence of the disease. Whenever the seed crop is planted in first fortnight of October it is subjected to the heavy incidence of diseases

and resulting poor seed yield. (Tomar and Negi 2002) has recorded the highest seed yield of 576.80 kg/ha with low incidence of diseases and better seed quality in cv. Pusa Madhavi in 15th November planting during *rabi* 1999. Kumar *et al.,* 2015 reported that 15th October is the ideal date of planting for onion cultivar Pusa Ridhi under Delhi condition. It showed significantly higher scape height, productive umbellate/umbel, seed setting (83.69%), seed yield/plant (8.71 g) and yield/ ha (6.86 q), and higher seed quality traits.

Integrated nutrient management

The ratio of N: P: K applied during seedbed preparation should be 1: 2:2 but the nitrogen ratio can be increased according to the status of the soil. Very limited work has been reported on the effects of nutrition in the first year on seed production in the second year. Ahmed (1982) showed that application of N: P: K @ 150 kg ha^{-1} produced the largest bulbs and highest total bulb yield at the end of first year and that supplementary N application not exceeding 100 kg/ha in second year applied during anthesis enhanced seed quality. Higher levels of N increased the seed yield both at the expense of seed quality. The high K levels during bulb production were carried over to the second year and enhanced seed quality.

Foliar spray of micro nutrients

Application of mineral nutrients is essential to fetch the higher yield and quality because Indian soils are deficient in micro nutrients. For better plant growth and development micro nutrients are needed in small quantities but their deficiency cause a greater disturbance in the physiological and metabolic processes and ultimately reduced seed yield and quality. Micro nutrients elements, especially B, Zn, Ca and Mg avoid antagonistic effects of nutrients during uptake from soil. In onion Kumar *et al.*, 2015 reported that foliar spray in combination of B+Zn+Ca+Mg (Recommended dose at 30 & 60 DAP) is beneficial for getting higher number of productive umbels, seed yield and quality.

Table 1: Effect of foliar spray of mineral nutrients on seed yield, quality and disease infection in onion cv. Pusa Riddhi

Treatments	Seed setting (%)	Seed yield/ umbel (g)	Seed yield/ ha (q/ ha)	Germination %	EC (µmhos/ cm/g)	Disease infected plants (%)
RD of B at 60DAP	83.82	3.33	7.03	90.08	1.85	15.5
RD of Zn at 60DAP	79.69	3.69	7.14	89.42	2.09	9.5
RD of Ca at 60DAP	81.41	3.74	7.25	89.00	1.82	12.5

Treatments	Seed setting (%)	Seed yield/ umbel (g)	Seed yield/ ha (q/ ha)	Germination %	EC (μmhos/ cm/g)	Disease infected plants (%)
RD of Mg at 60DAP	79.29	3.67	7.25	88.50	1.75	19.0
RD of B+Zn at 30 & 60DAP	89.05	3.64	7.48	90.40	1.68	10.0
RD of B+Zn+Ca at 30 & 60DAP	91.37	3.93	7.89	90.83	1.50	10.0
RD of B+Zn+Ca+Mg at 30 & 60	90.18	4.18	8.35	91.84	1.65	10.5
Control (Water spray)	78.13	3.17	6.00	86.83	2.32	24.0

Use of drip-irrigation and fertigation

The water management and fertigation studies have revealed that seed productions over low pressure drip/pressurized drip not only saves farm inputs but also increases the seed yield and quality. Tomar *et al*. 2004 realized that seed yield and quality of onion seed crop was the highest over drip irrigation method as compared to surface irrigation.

Variety	Drip irrigation		Surface irrigation	
	Seed yield/ plant (g)	Germination %	Seed yield/ plant (g)	Germination %
Onion cv. Pusa Madavi	94.61	92.13	44.08	79.75
Onion cv. RO-1	15.33	98	13.20	97

Hawthorn (1951) found that high soil moisture in the seedling year performed high seed yields. Borgo *et al*. (1993) reported that water stress during bulb sprouting and beginnings of the anthesis reduce the number of umbels and flowers/plant. However, in practice, the soil surface should not be continuously wet because it will predispose the crop to infection to root rot/damping off. The methods of irrigation also greatly influence the seed yield and seed quality of onion. Tomar *et al*. (2004) observed that drip method of irrigation gave higher seed yield (894.94 q/ha) than the surface irrigation (648.94 q/ha) in onion cv. Pusa Madhvi. The seed vigour index is also higher in drip (876.49) than surface (663.71) irrigation in onion cv. Pusa Madhvi.

Enhanced pollinator activity for higher seed yield

Onion is cross- pollinated in nature and bees, flies and other insects do pollination (Devi *et al*., 2015). It is essential to ensure that there is sufficient population of pollinating insects to achieve the full potential of onion seed. It is also possible in some situation

to encourage the development of increased blowfly population by distributing suitable carrier or dried fish among the flowering crop (Currah and Proctor, 1990).Pollination management is essential particularly for producing the hybrid seeds. In modern agriculture urbanization, more pesticide application and habitat loss have reduced the pollinator load per population which results in insufficient pollination of flower, less fruit and seed set and lower yield and quality in seed production plot. However, in order to increase seed set and seed yield 2-3 medium bee hives needs to be introduced in the periphery of seed production plot of cauliflower, cabbage and onion had shown better performance in seed yield and quality.The seeds from induced bee pollination showed high seed set (Prasad *et al*., 2000), maximum germination (Chandel *et al*., 2004), shoot and root length (Kalmath and Sattigi, 2004) as compared to control. Onion does not produce quality seed if insects do not visit the flowers. Chandel *et al*. (2004) reported that induced bee pollination increased seed yield by 2.5 times and produced on an average 971 seeds per umbel compared to 406 in the control. The seeds from induced pollination field resulted in 90 percent germination compared to 69.5 percent germination from the control.

Bulb weight and size

The bulb weight has markedly influenced the seed production in onion. The increases in bulb weight an increased the seed yield. Although an increase in weight and size of bulb results in higher seed yield, but very large size bulbs (< 90 gm) if used will need a very high seed rate (60 q/ha). Large size bulbs (3-4 cm diameter) and weighing < 90 gm may seed yield 10.00 q/ha,

Mulching

Black-gray, biodegradable plastic mulch enhance crop performance during winter season in north Indian condition coupled with drip irrigation lead to higher root growth and development of plant. Natural mulches like wheat or paddy straw mulching can be used in crops like onion for higher yield and quality seeds Anisuzzaman *et al*. (2009). Synthetic plastic opaque mulches do not allow the sunlight to pass and control weed effectively, they also raise the soil temperature and beneficial in areas prone to frost injury.

Quality Seed Production of Garlic

Garlic is a non flowering plant during course of evolution, domestication and anthropogenic selection has rendered the garlic plant as sterile. Though fertility is reported in garlic. The commercial success is still awaited. The apomictic nature of propagation has limitations in crop improvement and vegetative propagation has some inherent disadvantages like low rate of multiplication, additional cost incurred in bulk

storage and transportation, losses during storage, perpetuationof pest and diseases more important being the viruses.

Garlic Seed Production Techniques

1) Land requirements

Land used for seed production of garlic shall be free of volunteer plants.

2) Selection of planting material and bulb treatment

Bigger size cloves need to be selected. Studies indicate that the clove size has positive correlation with the bulb yield. The cloves should be treated with 2g/kg captan before planting.

3) Field Standards

Table 2: Contaminants and isolation distances

Contaminant	Minimum distance (m)	
	Foundation	Certified
Field of other varieties	5	5
Fields of the same variety not conforming to varietal purity, requirements forcertification	5	5

Specific Requirements

Factor	Maximum permitted %	
	Foundation	Certified
*Off types	0.10%	0.20%

*Maximum permitted at final inspection

4) Field inspection

A minimum of two inspections shall be made.

1. The first inspection shall be made when plants are large enough to verify isolation, offtypes including bolters and other relevant factors.
2. The second inspection shall be made when leaves begin to fall and before lifting of bulbs to verify isolation, off types and other relevant factors.

5) Climate and seasons:

Garlic is usually grown in *rabi* season however the planting time varies from region to region. In hilly region of Tamil Nadu garlic is grown in April-May and September and October. September to October in Madhya Pradesh, Maharashtra, Karnataka and Andhra Pradesh. September to November in Northern plains of India.

6) Planting method and seed requirement:

For better seed yieldthe cloves should be planted on raised bed with drip irrigation of 120 cm. The distance between the cloves should be 10 cm so that in a flat bed row 12 cloves can be planted and between rows spacing of 15 cm should be maintained. For planting one hectare area 500 kg seed is required.

Figure 1: *Garlic cloves are dibbled with hand on raised bed*

Figure 2: *Garlic seed crop on drip irrigation facilitates proper inspection*

7) Nutrient requirement

FYM 20 tons/ha, NPKS 100:50:50:50 kg/ha, apply 50:50:50 kg/ha NPK at the time of planting & remaining nitrogen in two splits, one at 30 days and 2nd at 45 days after planting.

8) Roguing

Plot should be visited regularly. Yellow and lanky plants should be removed; plants with differential maturity, height should be removed before.

9) Weed Management:

Spray Goal @ 1.5 ml/L after planting of cloves and one weeding after 45 to 60 day after planting should be done.

10) Curing and storage:

The garlic bulbs are harvested in the month of May and needs to be stored for 5-6 months. The plant after maturity must be left in the field for 3-4 days and shade curing by tying in bundles must be done for 15 days. The bulbs must be stored with leaves intact till planting.

11) Average Seed yield:

6-10 tons per hectare seed yield can be obtained. The yield largely depends on the variety used and the management practices.

12) Seed standards:

Indian Minimum seed certification standards according to seeds act 1966 is as below:

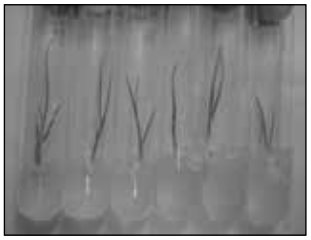
1. Average diameter of each bulb shall not be less than 2.5 cm or 25 g in weight.
2. Seed material shall be reasonably clean, healthy and firm, conforming to the varietal characteristics of the variety. The bulbs not conforming to varietal characteristics shall not exceed 0.1 and 0.20% (by number) for foundation and certified seed classes respectively.
3. Cut, bruised, cracked, immature or those damaged by insects, slug worms shall not exceed more than 2.0% (by weight).

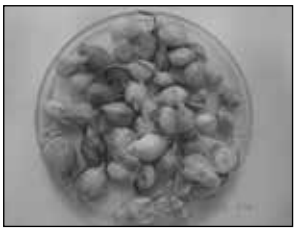
There are no seed standards with respect to germination and seed health particularly garlic viruses which are seed transmitted.

Virus free seed production by meristem culture

Garlic plants are usually infected by a mixture of viruses e.g., Onion yellow dwarf virus (OYDV, Potyvirus), Leek yellow stripe virus (LYSV, Potyvirus), Garlic common latent virus (GarCLV, Carlavirus), Shallot latent virus (SLV, Carlavirus), and mite-borne mosaic viruses (allexiviruses) which are collectively called as the garlic viral complex. Research studies suggest that elimination of virus leads to increase in yield and conservation estimates suggest that a yield increase of 30-70% is possible with virus free garlic as compared to its virus infested mother plants. Hence, development of virus free garlic from commercially cultivated garlic will be a good means to increase our productivity up to 8-9 t/ha, assuming a yield increase of 70% is achieved. Since the garlic is vegetatively propagated the infected cloves carry the disease to next season and new regions affecting the yield. The elimination of viruses from the garlic can be achieved by meristem culture. Since the meristem is usually devoid of virus, culturing the meristem in tissue culture laboratory eliminates the seed bore viruses. Its is usually done by the following process

Table 3: Virus free garlic seed production through meristem culture

1	Surface sterilization: the cloves is surface sterilized by sodium hypochlorite	
2	Meristem extraction: the virus free meristem is separated from the cloves	
3	Culturing in MS media with 1PPM Kinetin and 0.1 PPM NAA for 15 days	
4	Culturing in MS media for 20 days	
5	Bulbil induction: in MS media with 1PPM Kinetin	
6	Culturing in liquid media with kinetin 1PPM and 6% sucrose	

7	Bulbil harvesting and dormancy breaking by cold storage	
8	Hardening and Virus testing by ELISA/PCR techniques	
9	Field establishment and further multiplication	

Seed replacement with improved varieties in onion and use of virus free quality seeds in garlic can be one of thequickest ways to increase the productivity of onion. There is a need to diversify the onion seed production from traditional areas to neverareas for higher productivity, seed quality, and reduced disease incidence and to ensure the supply in the event of cop failure in traditional seed growing. By use of region specific refined technology the seed productivity can be enhanced. Adopting the seed village concept by encouraging the farmers at village level to entrepreneurship for enhanced income.

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Advance Technologies for Quality Seed Production of Potato

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Potato in India is grown in an area of about 2 mha with approximate production and productivity of 44 mt and 22 t/ha respectively. The quantity of quality seed required to cover entire area is around 6 mt @ 3 t/ha. This crop is cultivated under diverse agro-climatic conditions, major area of production being in the plains about 85% during short winter days from October to March. Plateau regions of south eastern, central, and peninsular India in autumn and rainy season occupies around 8% of the total cultivated area. The rest of the 5% area falls in the hills where the crop is cultivated during long days in summer from April to September. Therefore, major quantity of seeds is produced in the month of February and requirement of planting in month of October. In potato cultivation, seed tuber is the single most important factor in which accounts for nearly 40% of the investment for raising the crop.

Potato being a vegetatively propagated crop, the perpetuation of viral and other soil and tuber borne pathogens from year to year, which brings down the quality of seed stocks resulting in poor yields in subsequent generation of seed multiplication. The major vector responsible for the spread of viral diseases is aphid, which is almost absent during crop season in hills. Therefore, initially hills were the major source of healthy seed to the plains. Keeping in view the obvious problems of hill grown seed and the limited area available for healthy seed production in hills, efforts were made to produce healthy seed in plains. Survey was conducted in important potato growing areas of the country by CPRI from 1952 onwards which revealed a remarkable consistency in the aphid build up during the growing season. In northwestern and central Indo-Gangetic plains, the aphid population remained very low during October to December months. Taking full advantage of very low aphid population coupled with the use of improved cultural practices, it was possible to produce healthy seed in plains also. In 1959 seed plot technique was developed for production of quality seeds in the plains.

Seed Supply System in India

In India, broadly two type of seed supply system works.

Formal seed supply system

Formal seed supply system includes production of Nucleus and breeder seed by breeding Institutes i.e. CPRI and thereafter multiplying in Foundation-1 and Foundation-2 and Certified Seed by different seed producing agencies such as NSC, State Farm Corporations, States Horticulture/Agriculture departments, etc. In this system different stages are subjected to seed certification and it is ensured that the seed quality maintained as per Seed Act.

Informal seed supply system

Parallel to formal seed supply system there also exist informal seed supply system. Seed certification is not mostly followed and the supply of potato seed is mainly on the basis of the credit and individual reputation and belief of the farmers. Apart from this some private sectors organizations are also engaged in contract farming with farmers on assured buy-back policy.

This informal system may further be divided into two systems – (a) Unorganized system, where progressive, entrepreneurship farmers take lead in producing relatively better planting material and their reputation and liaison play major role in establishing seed supply linkages, (b) Organized system where private players are engaged in various models of contract farming in producing quality seed. Mostly they are well equipped with modern technology like tissue culture, aeroponics and high level of mechanisation.

Seed Production Technologies in India

Technologies of potato seed production have gone a sea changes in last decades. However, principally there are still two types of systems of seed production is in vogue i.e. Conventional system involves tuber indexing and field multiplication following seed plot technique. the Hi-tech system involves micro propagation in tissue culture lab, aeroponics and net houses. Under these systems seed tubers of following categories are produced

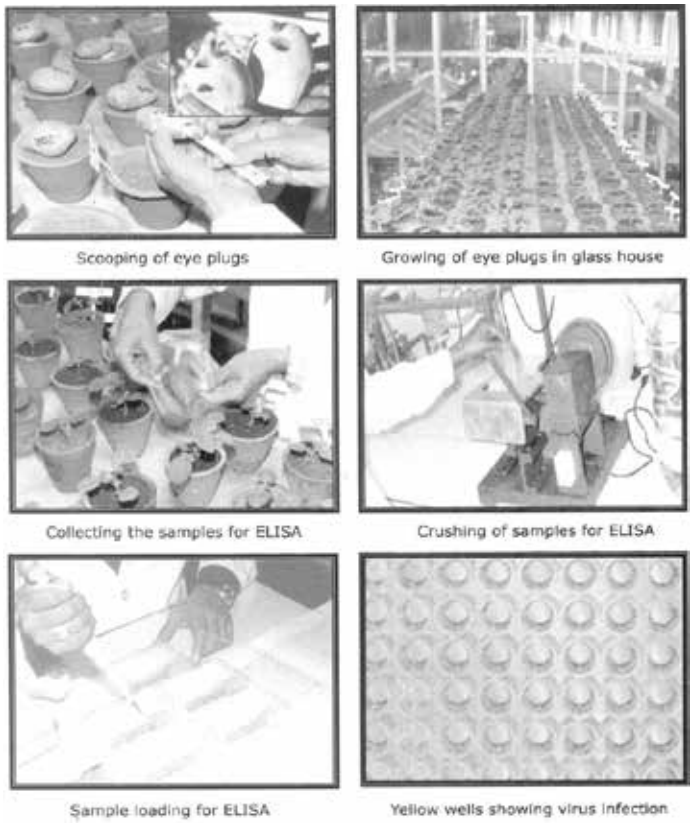
1. Nucleus seed
2. Breeder/Basic seed
3. Foundation seed
4. Certified Seed

These classes of seed are produced by government/non-government organization

Class of seed	Organization
Nucleus seed	Central Potato Research Institute
Breeder seed/basic seed	Central Potato Research Institute
Foundation –I	State Agricultural Universities (SAU), State Departments (Horticulture and Agriculture), National Seed Corporation (NSC) and State Farm Corporation of India (SFCI) etc
Foundation-II	State Departments (Horticulture & Agriculture), State Seed Corporation (SSC) and Cooperative Societies and NSC etc

Conventional seed production system

Nucleus seed: The nucleus seed is produced after tuber indexing in northern plains and hills. Nucleus seed is developed either through clonal selection, tuber indexing and two years field multiplication or through meristem tip culture and micro propagation.



Steps of tuber indexing

Breeders' seed: The produce of nucleus seed (stage-II) is multiplied in 3rd year as pre-basic seed in stage-III at a spacing of 100 x 20cm. This is further multiplied in 4th year in stage-IV. The produce of 4th year multiplication is called breeders seed.

Foundation seed (FS -I & FS -II): This is produced by state Agriculture/Horticulture departments & National Seeds Corporation. Among these organizations, Himachal Pradesh, Jammu and Kashmir, UP hills, Meghalaya, Manipur, Mizoram, Nagaland, Arunachal Pradesh & Sikkim are involved in hills under long day condition and UP, Bihar, Punjab, Haryana and MP, in the plains under short day condition.

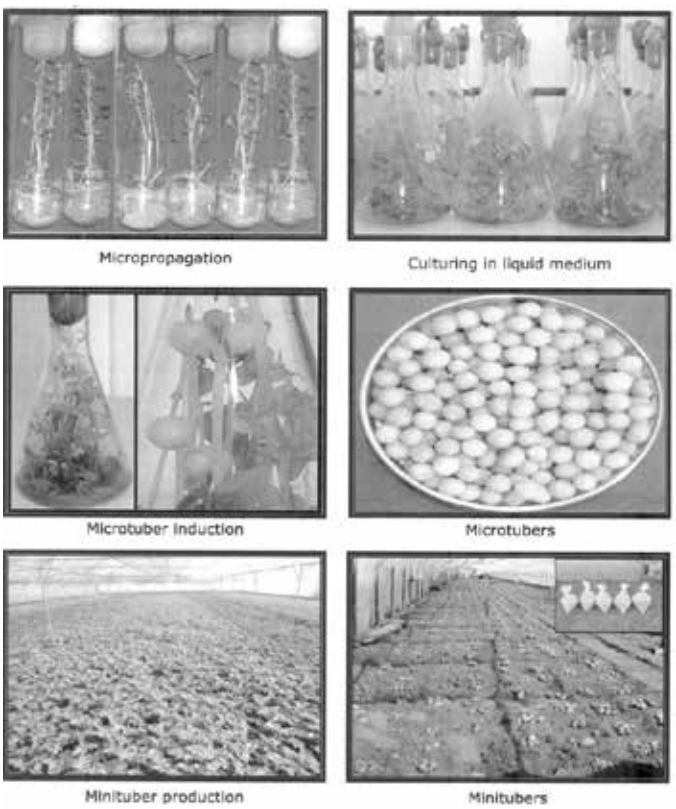
Certified seed: It is a further multiplication of foundation-II seed at registered growers field by following the package of practices for seed plot technique in the areas suitable for quality seed production. The FS- I and II seed is inspected and certified by State Seed Certification Agencies.

Hi-tech seed production system

In order to improve -the seed quality further and to reduce the field exposure, seed production through hi-tech system has been started. Under this system, there are three different sub-systems viz., i) Microplant based seed production system, ii). Microtuber based seed production system and, iii). Aeroponic based seed production system.

Micropropagation: Micropropagation allows large-scale asexual multiplication of pathogen-tested potato cultivars. At the interval of every 21 days of subculturing, minimum 3 nodal cuttings are obtained from a single micoroplant. Therefore, theoretically, 3^{15} (43 million) microplants can be obtained from a single virus-free mericlone in a year. Various techniques have been developed for producing large number of microplants on nutrient medium under aspetic conditions. The method involves culturing of nodal explants of disease-free microplants on semisolid (agarified) or liquid culture medium. MS medium is most widely used for potato microplant propagation. In vitro-derived microplants are used as (i) explant source for production of microtubers in vitro, (ii) direct transplants in the greenhouse for the production of minitubers, (iii) mother plants for further in vitro multiplication through single node cuttings (SNC's).

Microtuber production: Microtubers are miniature tubers developed under tuber inducing conditions in vitro. These small dormant tubers are particularly convenient for handling, storage and distribution. Unlike micropropagated plantlets, they do not require time-consuming hardening period in

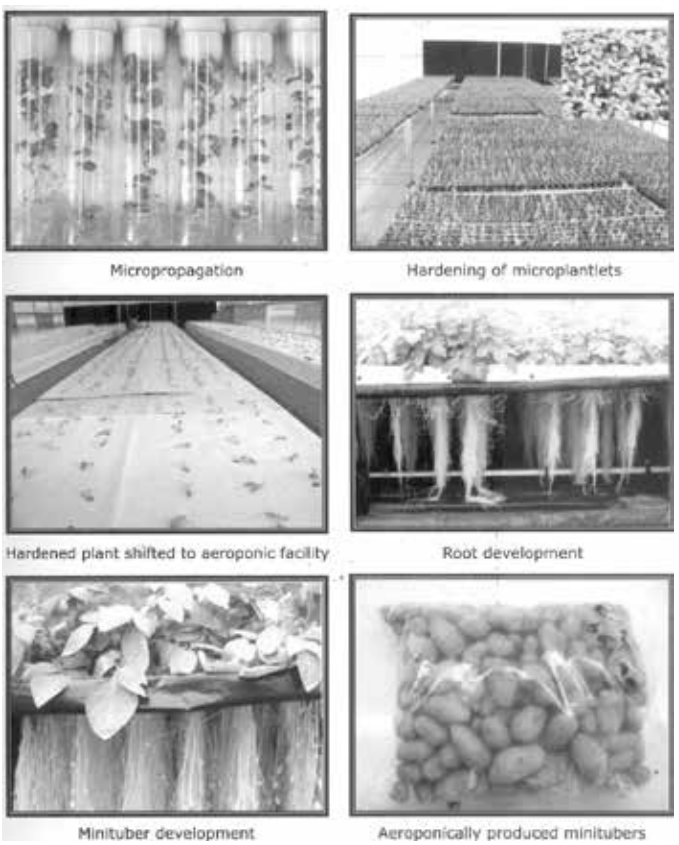


Hi-tech methods of potato seed production

the greenhouses, and may be adapted easily to large scale planting in the field. For the production of microtubers large number of microplants are produced in initial multiplication. 10-12 segments (each having 3-4 nodes) from six 21 day old plantlets are propagated in liquid media (20 ml) in 250ml In Erlenmeyer flask. In about 3 weeks all the axillary buds grow into full plants and fill the container. At this stage the liquid propagation media is decanted from the Erlenmeyer flask and tuber induction media is added. Microtuber induction media is based on MS basal nutrients supplemented with 10mg/l N^6-benzyladenine (BA), 500 mg/l Chlorocholine chloride (CCC) and 80 g/l sucrose. Incubate these induction cultures under complete darkness at 18-20°C. Microtubers start developing within 8-10 days and are ready for harvesting after 60-90 days. About 15-20 microtubers with an average weight of 100-150 mg are produced in each flask. Green the microtubers by putting them under white fluorescent light at 24°C for 10-15 days. Greening can be done both before or after harvesting. Microtubers are washed in clean water and treated with 0.2% Bavistin for 10 minutes and allowed to dry in dark before being cold stored at 4-5°C. After about 3-4 months of storage, the sprouted microtubers are ready for net-houses/ field planting.

Aeroponic in potato seed production

Aeroponics is a soil less system of growing plants where the plant roots are suspended in the air with a fine mist of nutrient solution applied either continually or intermittently over the root surface. Recently a lot of interest has been shown in aeroponics and for raising high quality disease free potatoes seed production it has been standardised. In this system, young hardened potato micro-plants from tissue culture or suitable plant cuttings (tender) are transplanted over the top of the growth chambers. Potato root system start developing down into the aeroponic chamber where it is regularly misted with nutrients. Nutrient solution after saturating the roots of the plants

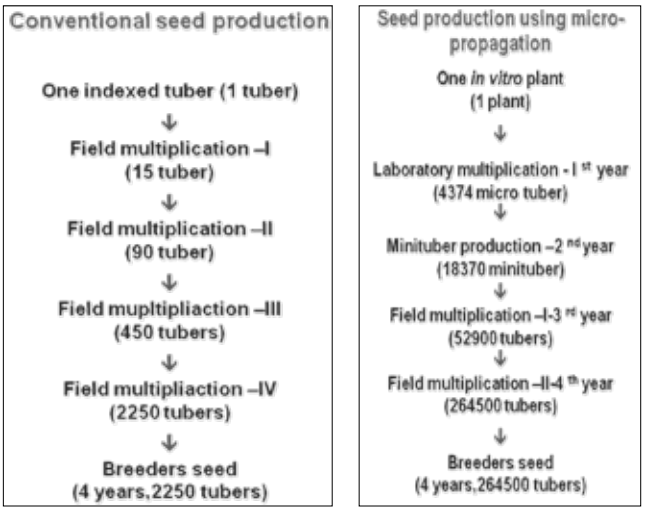


Aeroponic based seed production system

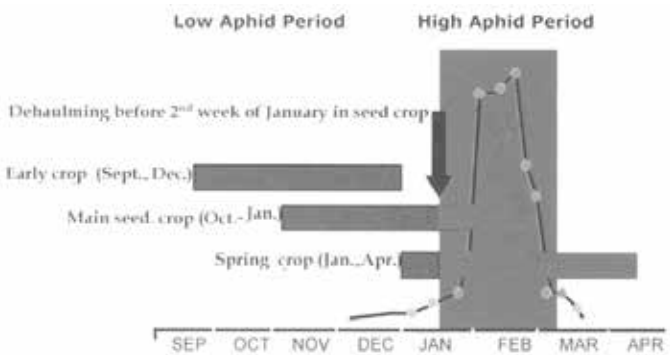
gets back, through the pipes, to the solution reservoir. In this way the same solution keeps circulating in this cycle passing through pump, filters, delivery pipes, nozzles, return pipes and strainers. Major advantages of this seed production system is that the rate of multiplication of minitubers is three to four times more as compared to microplants grown in soil under net houses. It prevents exposure to unfavourable soil conditions and the minitubers harvested from this system are free from all soil borne pathogens. It enables us to harvest desired size of minitubers which can be harvested sequentially and thus reduce the cost of minitubers production. These minitubers are planted in net house for multiplication.

Conventional Vs Hi-Tech system multiplication rates

In comparison to conventional method of seed production where 2250 tubers are produced from one indexed tuber in four year, whereas 264500 tubers can be produced in four years through Hi-tech system from single in vitro microplant. With integration aeroponic system with tissue culture in hi-tech system multiplication can further be increased by 4 to 5 times in a given period.



Seed Plot Technique (SPT): The technique of growing crop during low aphid period with healthy seed from October to first week of January coupled with the use of insecticides, rouging and dehaulming in the last week of December or upto second week of January is called as seed plot technique. Thus quality seed production was possible under this technique in sub tropical plains by advancing the date of planting from December end to first week of October.



Aphid population build-up during potato crop season in north Indian plains

Inspection and seed certification

Objectives: The main objective of seed certification is to control the spread of fungal, bacterial, viral and nematode

diseases to ensure production of good quality seed. In India, PYX, PVS, PVY, PVA, PVM and PLRV are important viral diseases. Amongst fungal diseases late blight, black scurf and dry rot are most important. Seed should be free from PSTV and cyst nematode

The general requirement seed certification is-

1. **Choice of aphid free locations and period:** In the hills, healthy seed production is taken up in the higher hills at 2500 m above msl. In such places, climatic conditions do not permit multiplication and spread of aphids (the virus vector). Besides, bacterial wilt pathogen also does not survive there. In the plains, the healthy seed can be produced during low aphid period from October to December, which is relatively free from aphids.

2. **Isolation:** Isolation of seed crop is very essential to avoid contamination. The seed crop should be separated from the crop of ware potatoes by a distance at least 20 meters. To avoid admixture between the variety, 5 meters distance is recommended between the two varieties of the same seed grade or category. This isolation will help to obviate mechanical mixture as well as spread of contagious viruses.

3. **Crop rotation:** Potato seed crop should not be grown in a field in which potato crop has been grown in the previous year. Suitable crop rotation will not only help in the elimination of soil borne pathogens but will also help to control the problem of ground-keepers which possess a problem for maintaining varietal purity in the hills. It is also desirable that solanaceous crop like tomato, chillies, brinjal and tobacco are not grown in the previous years.

4. **Variety and seed:** Only approved/released variety should be grown in the region for the production of healthy seed. The healthy seed of such varieties should be obtained from a reliable source like NSC or State Department of Agriculture/Horticulture.

5. **Cultural practices:** It is essential that all agronomic practices are adopted which helps to produce maximum yield of seed size tubers. Some of these practices are (i) pre-sprouting of seed tubers to ensure that thick, sturdy and multiple sprouts are produced. The tubers which develop hairy or abnormal sprouts should be discarded (ii) timely planting (iii) following suitable combination of seed size tubers and spacing. (iv) Judicious manuring, weeding, earthing and irrigation.

6. **Rouging:** Before final inspection for certification, minimum three rouging is required during the crop period. First rouging should be carried out soon after the completion of emergence. It should be done after 40-45 days and 30-35 days after planting in the hills and plains respectively. The second rouging is required after 60-65 days of planting in the plains and 70-80 days (at flowering) in the hills. Third rouging is done at near maturity when bolters are quite clear. During roguing all

atypical plants and those showing symptoms of mottling, mosaics, veinal necrosis, crinkle, rolling of leaves and development of purple or yellow colour should be removed. While rouging, the diseased plants are removed along with the tubers.

Plant protection measure: All plants protection measures which effectively control the spread and multiplication of insect vectors and other pathogens are to be compulsorily adopted.

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.

Breeder Seed: Breeder Seed is a 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 is not covered under certification. However the breeder seed crop is inspected by a monitoring-team consisting of the Breeder, representative of National Seeds Corporation and representative of Seed Certification Agency and nominees of crop coordinator. The crop is inspected at appropriate stages. The Breeder Seed is packed and supplied by the breeders. Breeder seed should not be used directly for producing certified class seed skipping foundation class.

Foundation Seed: Foundation seed is the progeny of Breeder seed, or be produced from foundation seed, which can be clearly traced to Breeder seed. The production is supervised and approved by the Certification Agency to conform the required certification standards viz. genetic purity, Physical purity etc. Thus, foundation seed can even be produced from foundation seed. During the production of Foundation seed, the following guidelines shall be observed.

- Foundation class seed produced directly from Breeder seed is designated as Foundation Seed Stage-1.
- Foundation seed produced from Foundation Seed Stage-I is designated as Foundation Seed Stage-II.
- Foundation Seed Stage-II is not be used for further increase of Foundation Seed and should be used only for production of Certified seed class.
- Minimum Seed Certification standards is same for both Foundation -I , II.
- **Certified class seed:** Certified Seed is the progeny of Foundation Seed and its production is handled so as to maintain specific genetic identity and purity according to standards for the crop.

Onion Improved Varieties, Production and Post Harvest Management

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Introduction

Onion is an important vegetable crop grown and consumed worldwide for its specific flavor and culinary properties. It is widely cultivated for domestic consumption as well as for export purpose. It has a very good export potential for earning a huge amount of foreign exchange to the country. Onion used a spices, condiments and vegetables almost daily in every kitchen for a wide variety of dishes. It is also a sensitive crop among vegetables that creates ripples in trade. The green leaves and immature bulb are also used for eating purpose. The major onion growing state are MS, Gujarat, Uttar Pradesh, Karnataka, M.P., Talmilnadu, Rajasthan, Andhra Pradesh and Odisha etc. India is presently one of the leading onions producing country and it is second after China. In production other countries are United States of America, Egypt, Iran, Turky, Russia, Japan and Pakistan. Onion is the single commodity in horticulture sector exported in large quantity throughout the year and earning foreign money. It is exported from India to neighboring countries like Bangladesh, Maleshia, Nepal, Sri Lanka and other Arabian countries. There are several varieties in onion such as red, brown, yellow and white from very strong to mild pungency. Onion is very important crop for human consumption.

Area, Production and Productivity

The total area and production of onion in world is 85.80 million tones from 4.4 million ha area with average productivity 19.31 tones/ha. In India the onion ranks second in area and third in production. India ranks second in total area and production after China in the world. In India as per estimate of year 2016-17, total production is 19.40 million tones from 1.20 million ha area with average productivity of 16.12 tones/ha. India is the largest production of short day onions globally which have genetically less production compared to the long day types that are grown in China. The major

onion growing countries in the world are China, USA, Iran, Russia, Turky, Egypt, Brazil, Netherland, Koria, Macico and Spain. The productivity of onion in world is highest in Republic Koria (64.58 tonnes/ha) followed by USA (54.47), Spain (53.69), Netherland (45.80), Japan (42.46), Germany (41.86) and Unitd Kingdom (41.15 tonnes/ha). The production of India is very low (16.12 tonnes/ha). As per estimates 2016-17 in India Maharashtra is leading state in area (38.88%) and in production (30.41%) with a productivity of 12.53 tonnes/ha followed by Madhya Pradesh, Karnataka, Gujarat, Bihar, Andhra Pradesh, Rajasthan, Haryana, Tamilnadu, Odisha, Telengana, UP and West Bengal. The availability of onion in the world is highest in Sudan with 91.80 kg/person/annum followed by Netherland (78.17kg), Tajikistan (50.35kg), Uzbekistan (36.93kg), Algeria (34.29kg), Iran (30.75kg), Morocco (28.17kg), Koria (26.27 kg), Turkey (25.42 kg), Spain (25.29 kg), Peru (24.63 kg), Egypt (23.19 kg), China (15.77 kg) and India (15.41 kg)

Trend of Area, Production, Productivity and per Capita Availability of onion

	India			World		
	2008	**2018**	**Increase (%)**	**2008**	**2018**	**Increase (%)**
Area (Lakh/ ha)	8.35	12.03	44.07	37.31	44.43	19.08
Production (Lakh/tones)	135.89	194.02	42.77	668.29	858.19	28.41
Productivity (tones/ha)	15.87	16.12	1.57	17.91	19.31	7.81
Per Capita Availability (kg/Person/year)	11.57	15.49	33.88	9.90	11.98	21.01

Improved Varieties of Onion developed in our country:

Sr. No.	Name of variety	Name of organization & Institutes	Suitable season	Year of release
		Red onion varieties		
1	Punjab Selection	PAU, Ludhiana, Punjab	*Rabi*	1973
2	Pusa Ratnar	IARI, New Delhi	*Rabi*	1975
3	Pusa Red	IARI, New Delhi	Late *Kharif* & *Rabi*	1975
4	Arka Kalyan	IIHR, Bangaluru	*Kharif*	1987
5	N-2-4-1	Deptt.ofAgri. MS	Late *Kharif* & *Rabi*	1985
6	Pusa Madhavi	IARI, New Delhi	*Rabi*	1987
7	Arka Niketan	IIHR, Bangaluru	*Rabi*	1987
8	Kalyanpur Red Round	CSA, University, Kanpur	*Rabi*	1983

Sr. No.	Name of variety	Name of organization & Institutes	Suitable season	Year of release
9	Agrifound Dark Red	NHRDF	*Kharif*	1996
10	Agrifound Light Red	NHRDF	*Rabi*	1988
11	NHRDF Red (L-28)	NHRDF	*Rabi*	2006
12	NHRDF Red-2 (L-355)	NHRDF	*Rabi*	2012
13	NHRDF Red-3 (L-652)	NHRDF	*Rabi*	
14	NHRDF Red-4 (L-744)	NHRDF	*Rabi*	
15	Hissar-2	HAU, Hisar	*Rabi*	1976
16	HOS-1	HAU, Hisar	*Rabi*	2006
17	Punjab Red Round	PAU, Ludhiana, Punjab	*Rabi*	1993
18	Punjab Naroya (PBR-5)	PAU, Ludhiana, Punjab	*Rabi*	1997
19	Arka Pragati	IIHR, Bangaluru	*Rabi*	1984
20	Arka Bhim (Triparental synthetic)	IIHR, Bangaluru	*Rabi*	2011
21	Arka Akshay (Triparental synthetic)	IIHR, Bangaluru	*Rabi*	2011
22	N-53	Deptt. of Agri. MS	*Kharif*	1975
23	Baswant 780	MPKV, Rahuri, MS	*Kharif*	1989
24	Udaipur 101	RAU, Udaipur	*Rabi*	
25	Udaipur 103	RAU, Udaipur	*Rabi*	
26	Phule Samarth	MPKV, Rahuri, MS	*Kharif* & Early *Rabi*	2006
27	VL-3	VPKAS, Almora, Nainital	*Rabi*	1990
28	VL-67	VPKAS, Almora, Nainital	*Rabi*	1973
29	Bheema Raj	DOGR, Rajgurunagar, Pune	*Kharif*	2007
30	Bheema Red	DOGR, Rajgurunagar, Pune	*Kharif*	2009
31	Bheema Super	DOGR, Rajgurunagar, Pune	*Kharif* & Late *kharif*	2006
32	Bheema Shakti	DOGR, Rajgurunagar, Pune	Late *kharif* & *Rabi*	2010
33	Bheema Kiran	DOGR, Rajgurunagar, Pune	*Rabi*	2010
34	Bheema Dark Red	DOGR, Rajgurunagar, Pune	*Kharif*	2012
	Bheema Light Red	DOGR, Rajgurunagar, Pune	*Kharif*	2015

Sr. No.	Name of variety	Name of organization & Institutes	Suitable season	Year of release
35	Rajasthan Onion-1 (RO-1)	PARS, Durgapura, Raj.	*Rabi*	2004
36	Arpita (RO-59)	PARS, Durgapura, Raj.	*Rabi*	2005
37	RO-252	PARS, Durgapura, Raj.	*Rabi*	2010
38	Selection 126 Brown	IARI, New Delhi	*Rabi*	2012
39	Selection 131	IARI, New Delhi	*Rabi*	
40	L-102	IARI, New Delhi	*Rabi*	
		Yellow Onion varieties		
1	Early Grano	IARI, New Delhi	*Rabi*	1975
2	Spanish Brown	IARI, New Delhi	*Kharif* & *Rabi*	1975
3	Phule Suvarna	MPKV, Rahuri, MS	Late *Kharif* & *Rabi*	2001
4	Arka Sona	IIHR, Bangaluru	*Rabi*	2011
5	Arka Pitambar	IIHR, Bangaluru	*Rabi*	2006
		White Onion varieties		
1	Pusa White Round	IARI, New Delhi	*Rabi*	1975
2	Pusa White Flat	IARI, New Delhi	*Rabi*	1975
3	Punjab 48	PAU, Ludhiana, Punjab	*Rabi*	1978
4	Punjab White	PAU, Ludhiana, Punjab	*Rabi*	1998
5	Udaipur 102	RAU, Udaipur	*Rabi*	
6	N-257-9-1	Deptt. of Agri. MS	*Rabi*	1985
7	Phule Safed	MPKV, Rahuri, MS	Late *Kharif* & *Rabi*	1994
8	Agrifound White	NHRDF	Late *Kharif* & *Rabi*	1994
9	PKV White	PDKV, Akola, MS	*Rabi*	2009
10	Gujarat White onion	GAU, Junagarh, Gujarat	*Rabi*	2000
11	Arka Swadista	IIHR, Bangaluru	*Rabi*	2010
12	Bheema Shweta	DOGR, Rajgurunagar, Pune	*Rabi* & *Kharif*	2010
13	Bheema Shubhra	DOGR, Rajgurunagar, Pune	*Kharif* & Late *kharif*	2010
14	Bheema Safed	DOGR, Rajgurunagar, Pune	*Kharif*	2014
		Small Onion Varieties		
1	Agrifound Rose	NHRDF	*Kharif*	1987

Sr. No.	Name of variety	Name of organization & Institutes	Suitable season	Year of release
2	Arka Bindu	IIHR, Bangaluru	*Kharif*	2006
3	Arka Vishwas	IIHR, Bangaluru	*Rabi*	2011
		Multiplier Onion Varieties		
1	Co-1	TNAU, Coimbatore, TN	*Kharif* & *Rabi*	
2	Co-2	TNAU, Coimbatore, TN	*Kharif* & *Rabi*	1978
3	Co-3	TNAU, Coimbatore, TN	*Kharif* & *Rabi*	1982
4	Co-4	TNAU, Coimbatore, TN	*Kharif* & *Rabi*	1984
5	Co-5	TNAU, Coimbatore, TN	*Kharif* & *Rabi*	1982
6	MDU-1	TNAU, Coimbatore, TN	*Kharif* & *Rabi*	1982
7	Agrifound Red	NHRDF	*Kharif* & *Rabi*	1987
8	Arka Ujjwal	IIHR, Bangaluru	*Rabi*	2010
		Onion Hybrids		
1	Arka Kirtiman	IIHR, Bangaluru	*Rabi*	
2	Arka Lalima	IIHR, Bangaluru	*Rabi*	
3	Arka Pitambar	IIHR, Bangaluru	*Rabi*	
4	Mercedes	Semminis, India	Late *Kharif* & *Rabi*	
5	Cougar	Semminis, India	Late *Kharif* & *Rabi*	
6	Colina	Nunhems, India	Late *Kharif* & *Rabi*	
7	Excalibur	Nunhems, India	Late *Kharif* & *Rabi*	
8	Lucifer	Bejo Sheetal, Jalna, India	*Rabi*	
9	Kristal	Nunhems, India	*Rabi*	

Strategies for Increasing Productivity and Minimising Post Harvest Losses

There is need to increase production by increasing productivity as also increase availability of onions for meeting domestic and export requirements. The availability of quality seed of onion in adequate quantities and extension education of farmers should be ensured by the seed production agencies and State Horticulture Departments.

Production Technologies

1. Use of quality seed of recommended variety for the area and season

Seed is since basic input it must be healthy. Farmers should be educated to procure quality seed of recommended varieties only for the different area and season. Agrifound Dark Red, L-883 and Arka Kalyan varieties are recommended for kharif season. Agrifound Light Red, NHRDF Red, NHRDF Red-2, NHRDF Red-3, Pusa Riddhi, Bhima Shakti , Arka Niketan etc are the varieties recommended for rabi season. Quality seed of these varieties should be procured from genuine sources.

2. Selection of land

Farmers have to select a land which should have deep friable and fertile soil. They should avoid selection of land having very light or heavy clay soil as such soils do not give good yield of quality bulbs. The PH of selected soil should be around 6.5-7.5.

3. Use of healthy nursery

Farmers should be advocated to grow nursery on their own and select healthy nursery having 6-7 weeks for kharif or 7-8 weeks for rabi season. Overaged nursery give rise to bolting resulting in reduced yield. In case of small onion, sowing should be done uniformly. Thick sowing should be avoided. Direct seedling is now being recommended for getting early crop. Direct seeders are also available in foreign countries and these machines have been imported by some agencies in India for use in onion with a view to reduce cost of cultivation.

4. Preparation of land

It is seen that farmers do not take proper care in leveling of land as also division of plot in small beds and channels. This results in no water at some places or more water creating stagnation at other places. Growth of the plants is ultimately affected. Diseases spread more severely when crop is not healthy. Farmers, therefore, need proper education on this.

5. Transplanting

Many times farmers either plant the crop early or late which does not give good required growth of plants resulting ultimately in reduced yield. Farmers should be advised to plant at a time recommended for the area. Sowing in June and transplanting in August is recommended for kharif whereas sowing in October and transplanting by December end is recommended for rabi.

6. Manures and fertilizers

25 t FYM and NPK @ 100:50:50 kg/ha has been recommend for normal soil. It is better to get the soil tested and then apply fertilizers and manures as per the recommendations.

FYM should be mixed one month before planting. ½ of N and full dose of P and K should be applied as basal dose and rest N in two splits i.e. at 30 and 45 days after transplanting.

7. Weeding

Timely weeding and hoeing is a most for good yield. 3-4 weeding and hoeing are must. Pendimethaline @ 3.5 l/ha 3 days after transplanting alongwith one hand weeding at 45 DAP has been recommended which should be advocated to farmers.

8. Irrigation

Onion is shallow rooted crop. It needs to be irrigated more frequently but each irrigation should be light. Field should never be water saturated. Water stress during bulbing should be avoided. In general, 2 acre inch of water per irrigation results in good yield.

9. Plant protection

Purple blotch and stemphylium blight are the major diseases. Spray of Mancozeb @ 0.25% or Chlorothalonil @ 0.2% or Iprodione @ 0.2% is recommended. Colleetotrichum blight is new disease in some pockets. Spray of Carbendazim @ 0.1% or Benlate @ 0.1% should be advocated. Mixing of Sticker Triton @ 0.06% is must for effective control. Thrips is a major insect pest. Application of Cypermethrine 25 EL @ 0.01% or Deltamethrine @ 0.01% alongwith Triton should be advocated.

10. Harvesting

Onion is harvesting depending upon the purpose it is to be used. For good yield, harvesting is done within 45-90 days from field setting for green onions and 65-150 days for bulb depending upon the variety and type. Bulb are considered mature when neck tissues begin to soften and tops are about to abscise and decolorize. For sale as dried bulbs in rabi, harvesting is done when top have started falling down. Best time to harvest rabi onion is one week after 50% tops have fallen down. In kharif, since there is no top fall, harvesting is done soon after the colour of leaves changes to yellow and tops start drying, red pigmentation on bulbs develop and true shape and size of bulbs develop.

Post- Harvest Technology of Onion

It is estimated that about 55-60% of onion comes from *rabi* season and 40-45% from kharif and late kharif season. Due to lack of proper post harvest management practices about 15-40 losses are occurred in various practices of onion handling. These losses can be reduced up to 15-20% after taking proper care in pre and post harvest management practices.

Pre-harvest practices

1. Selection of variety

Onion rabi season varieties like Agrifound Light Red, NHRDF Red, Bhima Super, Pusa Riddhi, NHRDF Red-2 and NHRDF Red-3 are suitable for good storage. The kharif onion varieties having low TSS content with less dried outer scales are generally poor in storage.

2. Seed Quality

The poor quality seed of any variety will produce more doubles, thick necked bulbs, bolters and poor developed bulbs. Thus to save the losses, good quality seed from genuine sources should be used for producing the quality bulb having longer shelf life.

3. Soil

Sandy soil is not suitable for producing good quality bulb for long storage. Clay loam soil should be preferred for the quality production of onion bulb with good keeping quality.

4. Fertilizer application

The nitrogenous fertilizers should not be applied more than the recommended dose 100 kg/ha. It will affect the keeping quality of onion bulb in storage. Potasik fertilizers are more useful for quality bulb production with longer storage. Application of nitrogenous fertilizers through top dressing should not be given after 50 days of transplanting. It reduces the storage quality of bulb.

5. Irrigation

Light and frequent irrigation at regular interval is good for improving the keeping quality of onion bulbs. The irrigation must be stopped 8-10 days before harvesting. Irrigation after maturity of crop must be avoided it will increase the losses due to more splitting and doubles. The drip and micro sprinkler system enhance the production and storage quality of bulb.

6. Chemical treatment

MH @ 2500 ppm at 75 days when applied reduces sprouting and bolting in kharif onion. Carbendazim @ 0.1% when sprayed in field at 90 days after planting, losses due to basal rot in store are reduced.

7. Harvesting

For the storage of rabi season onion bulb harvesting should taken up at one week after 50% top fall. If premature bulbs are harvested the driage and sprouting losses will

increase. The delayed harvesting may results splitting and bolting such bulb may not be kept for storage.

Post-harvest practices

1. Drying and curing

The purpose of drying is to remain excess moisture from outer skin and neck of onion bulb curing is an additional process of drying to developed the attractive skin colour and bulb scales. After harvesting, farmers should be advocated to cure onions in field by windrow method for 3-5 days. Care should be taken to cover the bulbs with the foliage to avoid sunscald. Bulbs are again cured for 10-12 days in shade before taking to store to remove field heat.

2. Cutting of tops

Tops should never be cut too close. It is good to leave about 2.0-2.5 cm top above the bulbs. Such bulbs store better than close top cut bulbs.

3. Sorting and grading

Doubles, bolted, immature and bulbs with no dried outer skin, diseased or damaged bulbs should be removed, Further, for storage, only medium size bulbs of 4.0-6.0 cm size should be preferred.

4. Storage of onion in stores having adequate ventilation

Onions require good ventilation in storage. Single tier of two tier structures with bottom and side ventilation constructed at raised platform are considered good for reducing losses. Whenever there are heavy rains, slope of roof should be such that bulbs do not get rain affected.

5. Development of disease and pest as well as moisture stress/heat resistant/ tolerant varieties

So far there is no such variety in onion which is considered as resistant/ tolerant to disease and pest or different stresses. Through efforts are on in NRC for onion and garlic at Rajgurunagar for development of diseases and pest resistant/ tolerant so also stress resistant / tolerant varieties, such work should also be initiated by the State Agricultural University in A.P. for solving the location specific problems.

6. Market support

Farmers will take required care if they get remunerative price for their produce. While continuation of regular export will help in stabilizing prices at an economic level, it is

necessary to introduce market intervention scheme if price below an economic level. Market support is necessary for sustaining the production and ultimately making the availability of sufficient stock for domestic and export supplies.

Constraints in Onion Production

The production and productivity of onion have increased substantially over the last 20 years. The productivity is still quite low compared to the Netherlands, USA, China, and Korea Republic etc. The constraints which have been identified for low production and productivity are as given below:

- Non-availability of high- yielding storable varieties for all the three seasons.
- Lack of strategy for expansion of area in kharif, late-kharif and Rabi seasons in non-traditional pockets.
- Non - availability of adequate quantity of quality seed of improved varieties.
- Onion varieties developed are not uniform in colour, shape and size.
- Bolting and doubles are observed in almost varieties. The marketable recovery thus is low.
- More varieties developed to grow under short day conditions (tropical conditions) compared to long day conditions in temperature countries where yield is higher.
- Due to tropical climate, disease and pest incidence are very high.
- No one variety developed in India has resistance to biotic and abiotic stresses.
- Non availability of high- yielding and storable F1 hybrids.
- All varieties are susceptible to disease and insect pests.
- Sub-optimal standards of cultivation adopted by farmers.
- Lack of high TSS in white varieties suitable for dehydration and high TSS in bigger sized bulbs of yellow varieties for export.
- Unseasonal rains.
- Inadequate storage facilities, transportation and marketing support.
- No regular Government policy on export.

एकीकृत बागवानी विकास मिशन एक परिचय

कृषि कल्याण मंत्रालय भारत सरकार द्वारा किसानों के लिए लाभकारी योजना

सुधीर कुमार सिंह एवं पी.के. गुप्ता

एन.एच.आर.डी.एफ., जनकपुरी, नई दिल्ली

रोजगाार तथा आजीविका सृजन में इसके उच्चांश के कारण कृषिकों को भारतीय अर्थव्यवस्था का मूलाधार माना जाता है। एकीकृत बागवानी मिशन, भारत कृषि कल्याण मंत्रालय भारत सरकार की लाभकारी एवं क्रांतिकारी योजना है।

एकीकृत बागवानी विकास मिशन (एम.आई.डी.एच.) फलों एवं सब्जियों, जड़ व कन्द फसलों, मशरूम, मसाले, फूल सुगंधित पौधों, नारियल, काजू, कोको और बांस इत्यादि उत्पादों के चौमुखी विकास की भारत सरकार को वित्तपोषित योजना है। पूर्वोत्तर और हिमालयी राज्यों को छोड़कर देश के सभी प्रदेशों में लागू इस योजना से जुड़े विकास कार्यक्रमों के कुल बजट का 85 प्रतिशत हिस्सा भारत सरकार देती है। जबकि शेष 15 प्रतिशत राज्य सरकारे खुद वहन करती है। पूर्वोत्तर और हिमालयी राज्यों के मामले में शत–प्रतिशत बजट केन्द्र सरकार ही वहन करती है। इसी तरह बांस विकास सहित राष्ट्रीय बागवानी बोर्ड (एन.एच.बी.) नारियल विकास बोर्ड एवं केंद्रीय बागवानी संस्थान नागालैंड और राष्ट्रीय एजेंसियां (एन.एल.ए.) के कार्यक्रमों के लिए भी शत–प्रतिशत बजटीय योगदान भारत सरकार ही करती है। जिससे किसानों के आत्मबल आर्थिक एवं मानसिक दोनों रूप से सदृढ़ बनाया जा सके।

एकीकृत बागवानी विकास मिशन के मुख्य उद्देश्य

- किसानों उत्पादकों की उचित आय को सुनिश्चित करने के लिए संहत क्षेत्रों को विकसित कर एक छोर से दूसरे छोर तक सर्वांगीण विकास को सुनिश्चित करना।

a) बागवानी क्षेत्र के चौमुखी विकास को बढ़ावा देना जिसमे बांस और नारियल भी शामिल है। इस क्रम में प्रत्येक राज्य अथवा क्षेत्र की जलवायु विविधता के अनुरूप क्षेत्र आधारित अलग–अलग कार्यनीति अपनाना जैसे – अनुसंधान एवं तकनीक को बढ़ावा एवं विस्तारीकरण, फसलों परांत प्रबंधन एवं प्रसंस्करण और विपणन इत्यादि।

b) किसानों को एफआईजी, एफपीओ व एफपीसी जैसे कृषक समूहों से जुड़ने के लिए प्रोत्साहित करना ताकि समानता और व्यापकता आधारित आर्थिकी का निर्माण किया जा सके।

c) बागवानी उत्पादन की उन्नति कृषक संख्या में वृद्वि एवं आमदनी और पोषाहार सुरक्षा।

d) गुणवत्ता, पौध सामग्री और सूक्ष्म सिंचाई के प्रभावी उपयोग के जरिये उत्पादकता सुधार।

e) बागवानी क्षेत्र में ग्रामीण युवाओं में मेधा विकास को प्रोत्साहन देना और रोजगार उत्पन्न करना।

f) फसलों परांतशील श्रृंखला के क्षेत्र में उचित प्रबंधन आधुनिक वैज्ञानिक जानकारी के माध्यम से प्रौद्योगिकी को बढ़ावा एवं विकसित करना और इनका प्रसार प्रचार करना। पारम्परिक फसलों के क्षेत्रों को बागों एवं पुष्पों एवं सब्जियों और मसालों के उत्पादन क्षेंत्रों में परिवर्तित करना।

g) पोस्टहार्वेस्ट हानियों को कम करना एवं उनके भण्डारण व्यवस्था हेतु ढांचागत सुविधाओं को प्रोत्साहन। बागवानी विकास के लिए चल रहे अनेक योजनाबद्ध कार्यक्रमों को आपस में सहक्रियाशील रूप में बनाना तथा दूसरों की ओर अभिमुख होकर काम करने के लिए प्रोत्साहित करना।

एकीकृत बागवानी विकास मिशन किसानों की आर्थिक स्थिति सदृढ़ कराना और उत्पादन को बढ़ावा देने के लिए अलग–अलग घटकों पर कृषि किसान मंत्रालय, भारत सरकार राज्यों को सब्सिडी एवं सहायता प्रदान कर रही है। निम्नलिखित घटको जैसेः–

1. उत्पादन एवं उत्पादकता सुधार
2. पौध सामग्री का उत्पादन और वितरण
3. सब्जी बीज उत्पादन
4. जल स्रोतों का निर्माण
5. संरक्षित खेती
6. सीड इन्फ्रास्ट्रक्चर की स्थापना
7. नवीन उद्यान रोपण
8. स्माल नर्सरी की स्थापना
9. प्रदर्शन के जरिये तकनीक की अधिकाधिक प्रसार
10. प्रसंस्करण व मूली संबद्व

11. पुष्प क्षेत्र विस्तार कार्यक्रम

12. मशरूम कम्पोस्ट मेकिंग यूनिट

13. कोल्डरूम (स्टैगिंग)

14. फसलोंपरांत प्रबंधन

15. शीतगृह भंडराण संरचना

16. बजार के आधारभूत ढांचे का निर्माण

17. संस्थागत सुदृढ़ीकरण एफपीओ का गठन

18. बागवानी में मानव संसाधन विकास (एच.आर.डी.) मधु मक्खी पालन के जरिये परागण

19. बागवानी का यंत्रीकरण सेमिनार कार्यशाला

20. प्रदर्शनी

21. विकास कौशल योजना से युवाओं को स्वरोजगार पैदा करना

इन योजनाओं के बारे में हर किसान को जानना और समझना चाहिए ताकि इसका लाभ किसान सही मायने पर ले सकें। योजनाओं के बारे में जानने के लिए https://midh.gov.in साइट पर जाकर विस्तृत जानकारी लिया जा सकता है। इस योजना के लाभ किसान अपने राज्य एवं जिला के उद्यान विभाग के माध्यम से जानकारी ले सकते है। भारत सरकार की यह योजना सभी राज्यों में चल रही है। इसमें राष्ट्रीय स्तर की एजेंसियाँ भी कार्य कर रही है। आपके राज्य एवं जिला में उनका कार्यालय हो तो वहाँ जाकर जानकारी लेकर उसका पूरा लाभ उठा सकते है। इस योजना की जानकारी राज्य सरकार की वैबसाइट पर उपलब्ध है सभी किसान भाई उस वैबसाइट पर या किसान कॉल सेंटर पर कॉल करके भी जानकारी ले सकते हैं कि आपके राज्य में इस योजना के तहत सब्सिडी या सहायता दी जा रही है।

राष्ट्रीय स्तर की एजेंसियों में राष्ट्रीय बागवानी अनुसंधान एवं विकास प्रतिष्ठान (एन.एच.आर.डी.एफ.) की भूमिका

राष्ट्रीय स्तर की एजेंसी के रूप में राष्ट्रीय बागवानी अनुसंधान एवं विकास प्रतिष्ठान को विभिन्न योजनाओं को किसान को लाभन्वित कर रहा है जिससे उनकी आय बढ़ाने में सहायता मिल रही है।

एन.एच.आर.डी.एफ. द्वारा संचारित योजनाएं निम्नलिखित हैः–

- उत्तम किस्म के बीजों के उत्पादन और आपूर्ति सहित सब्जियों के विकास से संबंधित क्रियाकलापों विशेषरूप से प्याज एवं लहसुन की बीजों में किया जाता है जिसमें किसान के उच्च कोटी के बीज उपलब्ध कराये जाए जिससे उनका उत्पाद बढ़ सके।

- किसान प्रशिक्षण कार्यक्रम के तहत किसानों को दूसरे राज्य ले जाकर ब्लॉक एवं गांव स्तर प्रगतिशील किसान के खेतों पर दौरा कराया जाता है और भारत सरकार के अन्य उद्यम में घुमाया जाता है जिस से खेती की नई तकनीक अपनाने कृषि वैज्ञानिक के माध्यम से उन्हें शिक्षित किया जाता है उन्हें नई किस्म के बारे में बताया ओर दिखाया जाता है जिससे किसानों की उत्पाद को बढ़ाया जा सके।

- प्रौद्योगिकी प्रसार प्रदर्शनी के माध्यम से किसानों को जागरूक कराना, नये किस्म के बीजों एवं नए तकनीक के विषय में विस्तारपूर्वक दिखाया जाता है। किसानों की जमीन खेत पर प्रदर्शन के माध्यम से (बागवानी फसलों से मिलने वाले फायदे दिखा कर जागरूक किया जाता है।

- कौशल विकास के माध्यम से कृषि क्षेत्र में स्वरोजगार का अवसर प्रदान कराना एवं मशरूम खेती, माली नर्सरी प्रशिक्षण, मधुमक्खी कौशल विकास योजना कार्यक्रम के तहत युवाओं को प्रशिक्षित किया है। जिससे स्वरोजगार का अवसर प्रदान हो।

- प्रसार एवं प्रचार के माध्यम से एन.एच.आर.डी.एफ. ने एम.एच.डी.आई. कैम्पेन शुरू की है जिससे ब्लॉक स्तर एवं गॉव स्तर पर किसानों को योजनाओं के बारे में जानकारी देना ओर योजना का लाभ कैसे ले सके उसके बारे में बताया जाता है।

- राज्यस्तरीय ओर राष्ट्रीय स्तरीय संगोष्ठी का आयोजन किया जाता है जिससे किसान सेमिनार में सम्मलित होकर इसका लाभ उठायें। किसान सेमिनार में आये वैज्ञानिक से प्रत्यक्ष रूप से अपने प्रश्न पूछ सकते है। पीपीटी के माध्यम से नई तकनीक दिखाई जाती है जिससे किसान उत्पादन में बढ़ोत्तरी कर सके।

- राष्ट्रीय बागवानी अनुसंधान एवं विकास प्रतिष्ठान (एन.एच.आर.डी.एफ) किसानों की आर्थिक स्थिति में विकास एवं मार्गदर्शक में हमेशा अग्रसर रहता है।

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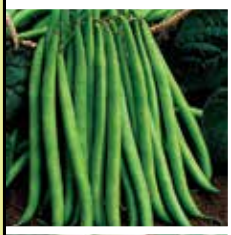


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