Technological Options for Enhanced Productivity and Profit

Indian Agricultural Research Institute
New Delhi - 110 012

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Technological Options for Enhanced Productivity and Profit

Second Revised Edition

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Concept and Guidance

Dr. H.S. Gupta
Director

Supervision

K. Vijayaragavan
Joint Director (Extension)

Compilation and Editorial Team

N.V. Kumbhare
C.B. Singh
Monika Wason
J.P. Sharma
Harish Kumar
V. Sangeetha

Photography : T. Dasgupta

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शरद पवार
SHARAD PAWAR

सत्यमेव जयते

कृषि एवं खाद्य प्रसंस्करण उद्योग मंत्री
भारत सरकार
MINISTER OF AGRICULTURE &
FOOD PROCESSING INDUSTRIES
GOVERNMENT OF INDIA

MESSAGE

Agriculture has been one of the major contributors to the country's efforts towards inclusive growth. Enhancing farmers' accessibility to innovative farm technologies and quality information is essential to boost the farm productivity and income. Today, new opportunities exist for greater growth and development in agriculture through diversification towards high value commodities, commercialization and integration with local markets. In order to help farmers to exploit the opportunities, it is imperative to augment speedy deployment and utilization of implementable innovative farm technologies. In this context, it is heartening to know that the first edition of the publication entitled, "**Technological Options for Enhanced Productivity and Profit**" brought out by IARI has received an overwhelming response among farming community and extension professionals. In order to meet the growing demand of this publication, I am glad that the IARI is bringing out the revised second edition of the above publication, which provides the details of appropriate technologies offered to the farming community under different situations to meet the information needs of farmers, entrepreneurs and extension workers throughout India.

I congratulate the IARI for its pursuit towards agricultural development and farmers' prosperity through various research and developmental efforts. I am sure that this publication will also become trend setter in helping farmers to adopt suitable technological options in order to enhance their production, productivity and profit.

March 29, 2012
New Delhi

(SHARAD PAWAR)

Office : Room No. 120, Krishi Bhawan, New Delhi-110 001 Tel.: 23383370, 23782691 Fax : 23384129
Resi. : 6, Janpath, New Delhi-110 011 (India) Tel. : 011-23018870, 23018619 Fax : 011-23018609
E-mail : sharadpawar.sp@gmail.com

सत्यमेव जयते

डा. एस. अय्यप्पन
सचिव एवं महानिदेशक
Dr. S. AYYAPPAN
SECRETARY & DIRECTOR-GENERAL

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि मंत्रालय, कृषि भवन, नई दिल्ली 110 114

GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRI CULTURE, KRISHI BHAVAN, NEW DELHI 110 114
Tel.: 23382629; Fax: 91-11-23384773
E-mail: dg.icar@nic.in

FOREWORD

It is heartening to note that the country has achieved a record production of 244.78 million tonnes of food grains during 2010-11. Apart from the growth achieved for food grain production, significant progress has been made in the areas of horticultural crops, animal husbandry and fisheries. In order to sustain the achievements made in the farming sector and to meet the livelihood security of the ever burgeoning population of the country, there is a need to continually develop innovative technologies. The pivotal role of IARI in development of cutting edge technologies for ensuring agricultural prosperity is well known. The new technologies will benefit the farming community only if they are accessible and made available. An effective flow of information and availability of technological support is the need of the hour. The farmers of the country need to be updated with the latest technological knowhow, which will help them to manage emerging issues related to production, value addition and marketing.

I am glad that IARI is bringing out the revised second edition of "**Technological Options for Enhanced Production and Profit**" in response to its demand by the farming community, extension personnel and developmental workers. I am confident that the publication will benefit farmers, extension workers and officials of state department in enhancing both agricultural production and farmers' income.

March 26, 2012
New Delhi

(**S. Ayyappan**)

भारतीय कृषि अनुसंधान संस्थान, नई दिल्ली-110012 (भारत)
INDIAN AGRICULTURAL RESEARCH INSTITUTE
(A University Under Section 3 of UGC Act. 1956)
NEW DELHI-110012 (INDIA)

हरि शंकर गुप्त, पीएच.डी. (आई.आई.टी.), एफ.एन.ए.ए.एस.
निदेशक

H.S. Gupta, Ph.D. (IIT, KGP), FNAAS
Director

Phones : (Off.) 011-2584 2367, 2584 3375
(Res.) 011-2584 6774, 2584 3978
Fax : +91-11-2584 6420
E-mail (off.): director@iari.res.in
personal : hsgupta.53@gmail.com

PREFACE

Agriculture continues to be an integral component of the national economy and livelihood of millions of people. Sustenance of food security and farmers' prosperity need concerted attention keeping in view the challenges faced by the present day farming. Strategic interventions are required to secure enhancement in farm productivity and income. The Indian Agricultural Research Institute has been striving for a holistic approach to meet agrarian challenges through technology and policy based solutions. The new crop varieties, hybrids and other technologies developed by the Institute combined high yield with resistance/tolerance to biotic and abiotic stresses and enhanced nutritional quality to consolidate farmers' gain, profitability, food and nutritional security. The Institute has made several initiatives to meet the new challenges of changing climate, shrinking natural resources, emerging pests and increasing demand for high quality agricultural produce.

The transfer of technologies continues to get high priority of the Institute as improved technologies need to be adopted by farmers to make a real impact on agricultural economy. Keeping this in view, the Institute has initiated several extension programmes and technology transfer models.

I am delighted to learn that the first edition of technology bulletin "**Technological Options for Enhanced Productivity and Profit**" has been a great success in meeting the information needs of farming community as well as extension professionals. This has necessitated bringing out this revised edition of the above publication to meet the demands of different stakeholders in agricultural development in all parts of the country. This bulletin provides brief and appropriate information on improved crop varieties and their production technologies, efficient plant protection techniques, useful agricultural equipments and agricultural extension services for generating higher income and employment in the rural sector.

I thank all joint directors, project directors, heads of divisions and regional station, incharges of units and scientists for making the required information available for this publication. I appreciate the efforts of Dr. K. Vijayaragavan, Joint Director (Extension) and his team of scientists in collecting and compiling the information. I hope, this publication will benefit all the concerned and contribute to driving Indian agriculture on a higher path of growth.

March 26, 2012
New Delhi

(H.S. Gupta)

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Introduction

The Indian Agricultural Research Institute, popularly known as Pusa Institute, has been the premier institution for agricultural research, education and extension in India. The Institute occupies a unique position in the country as a centre for research, post-graduate education and extension. During its over 106 years of existence, IARI has attained great heights in various fields of its endeavours.

The Green Revolution was born in the fields of IARI with the development of the famous high yielding dwarf Pusa wheat varieties such as Kalyan Sona and Sonalika. This has resulted in the country's achieving food security and creating buffer stocks. The Indian Agricultural Research Institute has continued its efforts in developing high yielding, climate resilient crop varieties combining resistance to both biotic and abiotic factors and enhanced nutritional quality, towards achieving the targets of the 'National Food Security Mission' to increase the production of rice by 10 million tons, wheat by eight million tons and pulses by two million tons by the end of the Eleventh Five Year Plan.

The IARI rice variety Pusa 1121 dominates the global Basmati rice trade. During the last crop season, this variety was grown by the farmers on about 1.35 million hectares, which secured 5.8 million tonnes of Basmati rice worth ₹ 11,600 crores. A new Basmati rice variety Pusa 1509 is expected to give a fillip to the cultivation and trade of Basmati rice. It has the advantage over Pusa Basmati 1121 in terms of earliness by twenty days, non-shattering and non-lodging habit and superior grain and cooking quality. Pusa Rice Hybrid 10 (PRH 10) has already gained popular acceptance among the farmers for its threefold increase in yield, short duration and reduced cost of cultivation due to saving of inputs like fertilizers, irrigation and pesticides. Pusa 1460, a variety resistant to devastating bacterial leaf blight disease, has higher production potential (6.0-6.5 tonnes/ha).

A new wheat variety HD 2967 was released for North-Western Plains Zone to replace the dominant PBW 343, which has become highly susceptible to yellow and stem rusts. HD 2967 has an average yield of 5.5 t/ha with excellent chapati making quality and high iron and zinc content. During the crop season 2010-11, thousands of farmers of Punjab and Haryana, who had grown HD 2967, reported that this variety stood resistant against yellow rust while other wheat varieties suffered heavy losses. This variety has become a boon to the farmers in terms of its resistance to yellow rust, and confirmed field resistance to Ug99 from Kenyan and Ethiopian data over the last three years.

The Institute supplied a large quantity of seed of this variety by focusing on Punjab through our extension system and has already taken up a programme to produce 200 tonnes of seed of HD 2967 for distribution to farmers during Rabi 2012-13. Apart from developing high yielding crop varieties, IARI has provided national leadership in input management activities, cropping system research, water resource mapping, pesticide residue analysis and issues related to global climate change. It also introduced biotechnology for crop improvements in India through its research on genetic mapping, molecular markers, genome sequencing and transgenic development.

A real impact on agricultural economy can be made only if improved technologies are adopted by our farmers. Capacity building and technological backstopping of the farmers will remain the Institute's priority. We adhere to our commitments to disseminate novel agricultural technologies to the farmers to ensure higher agricultural productivity and prosperity for our farmers. The Institute published first edition of technology bulletin entitled, "**Technological Options for Enhanced Productivity and Profit**", which has been a great success in meeting the information need of farming community and extension professionals. This has necessitated bringing out this revised edition of the above publication to meet demands of different stakeholders in agricultural development in all parts of the country. This bulletin is a valuable publication written in a very simple and farmer- friendly style. It provides brief information on improved crop varieties (including vegetables, fruits and flowers), efficient plant protection techniques, agricultural extension services and useful agricultural implements.

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Improved Crop Varieties for Higher Productivity

The Indian Agricultural Research Institute (IARI) has continued to face the challenges of developing and improving crop varieties and hybrids for enhancing production under changing needs and meeting the demands of a rapidly growing population. In 2010-11 the country recorded food production of 244.78 millon tonnes. The Institute has made significant contributions to the development of improved cultivars and their relevant production, protection and processing technologies on a sustainable basis in fourteen mandated crops covering cereals, coarse millets, pulses, oilseeds, fodder and fibre crops. All these crops have been widely adopted in their recommended areas. Crop-wise description of some of the important released varieties of these crops is given below :

Cereal Crops

Wheat

During the year 2010-11, wheat was cultivated in an area of 29.25 million hectares in our country with a production of 86.87 million tonnes of grains and a productivity of 2.93 tonnes/hectare. Much higher yields have been recorded in Front-line Demonstration programme by adoption of existing improved technologies. About 100 varieties of wheat have been developed and released from IARI for enhancing production and productivity. By using good quality seeds of improved varieties and the latest agronomic practices, productivity can be greatly enhanced. Area wise details of the improved varieties developed at IARI are given below :

North Western Plains Zone

HD 2967

Year of release : 2011

Recommended areas : Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), plains of J&K, H.P., Uttrakhand, Eastern U.P., Bihar, Jharkhand, Orissa, West Bengal, Assam and plains of NE states

Production conditions : Timely sown irrigated

Average yield : NWPZ 5.0 t/ ha, NEPZ 4.4 t/ha

Characteristics : Widely adapted variety, carries diversified genes other than 1B/1R. Possesses very high adult plant resistance against most prevalent leaf rust disease as well as of 78S84 and 46S119, two most virulent races of yellow rust disease. It has also better degree of resistance against leaf blight. It matures in 129 days (NEPZ) & 143 days (NWPZ).

HD 2894 (Pusa Wheat 109)

Year of release : 2008 (SVRC)
Recommended areas : National Capital Region of Delhi
Production conditions : Timely sown irrigated
Average yield : 5.2 t/ha
Characteristics : Resistant to leaf rust disease. It is a non 1B/1R line and therefore, has no sticky dough.

HD 2851 (Pusa Vishesh)

Year of release : 2005 (SVRC)
Recommended areas : National Capital Region of Delhi
Production conditions : Timely sown irrigated
Average yield : 5.6 t/ha
Characteristics : Resistant to all the three rusts.

WR 544 (Pusa Gold)

Year of release : 2003 (SVRC)
Recommended areas : National Capital Region of Delhi
Production conditions : Late and very late sown irrigated
Average yield : 3.7 t/ha
Characteristics : Early maturing (fits well in intensive cropping system); possesses terminal heat tolerance, high level of resistance to leaf and stem rusts, and leaf blight.

HD 2687 (Shresth)

Year of release : 1999 (CVRC)

Recommended areas : Punjab, Western Uttar Pradesh (except Jhansi division), Haryana, Rajasthan (except Udaipur and Kota regions), Delhi and plains of Uttarakhand, H.P. and J&K

Production conditions : Timely sown irrigated

Average yield : 5.5 t/ ha

Characteristics : Dwarf in height (95 cm), medium maturity (138 days), tolerant to lodging; durable resistance to leaf and stripe rusts and tolerance to Karnal bunt.

North Eastern Plains Zone

HD 2985 (Pusa Basant)

Year of release : 2010 (CVRC)

Recommended areas : Eastern U.P., Bihar, Jharkhand, Orissa, Sikkim, West Bengal, Assam and plains of NE states

Production conditions : Late sown irrigated

Average yield : 3.5-4.0 t/ha

Characteristics : It has the lowest reduction in the 1000-grain weight under very late sown conditions. The variety possesses the usable and most practical type of disease resistance, viz., the adult plant resistance (APR) because of *Lr13*. It matures in 105-110 days.

HD 2888 (Pusa Wheat 107)

Year of release : 2006 (CVRC)

Recommended areas : Eastern U.P., Bihar, Jharkhand, Orissa, Sikkim, West Bengal, Assam and plains of NE states

Production conditions : Timely sown rainfed

Average yield : 2.25 t/ha

Characteristics : High degree of resistance to leaf and stem rusts and moderate resistance to stripe rust, high extraction (flour recovery) without disturbing the quality and micro nutrient contents. It matures in 135-140 days.

HD 2824 (Poorva)

Year of release : 2004 (CVRC)

Recommended areas : Eastern U.P., Bihar, Jharkhand, Orissa, Sikkim, West Bengal, Assam and plains of NE states

Production conditions : Timely sown irrigated

Average yield : 4.6 t/ha

Characteristics : Plasticity to delayed sowing, suitable for rice-wheat cropping system. Tolerant to rusts and leaf blight. It matures in 130-135 days.

HW 2045 (Kaushambi)

Year of release : 2002 (CVRC)

Recommended areas : Eastern U.P., Bihar, Jharkhand, Orissa, Sikkim, West Bengal, Assam and plains of NE states

Production Conditions : Late sown irrigated

Average yield : 4.1 t/ha

Characteristics : Early maturing and possesses terminal heat tolerance, high level of resistance to leaf rust, stem rust and leaf blight. It matures in 110-115 days.

HD 2733(VSM)

Year of release : 2001 (CVRC)

Recommended areas : Eastern U.P., Bihar, Jharkhand, Orissa, Sikkim, West Bengal, Assam and plains of NE states

Production conditions : Timely sown irrigated

Average yield : 5.0 t /ha

Characteristics : Double dwarf (82 cm) with medium early maturity (130-135 days), resistant to leaf rust and leaf blight.

HP 1761 (Jagdish)

Year of release : 1997 (CVRC)

Recommended areas : Eastern U.P., Bihar, Jharkhand, Orissa, Sikkim, West Bengal, Assam and plains of NE states

Production conditions : Timely sown irrigated

Average yield : 4.27 t/ha

Characteristics : Moderately resistant to rust and leaf blight. It matures in 125-130 days.

HP 1744 (Rajeshwari)

Year of release : 1997 (CVRC)

Recommended areas : Eastern U.P., Bihar, Jharkhand, Orissa, Sikkim, West Bengal, Assam and plains of NE states

Production conditions : Late sown irrigated

Average yield : 4.0 t/ha

Characteristics : Resistant to brown and yellow rusts and tolerant to leaf blight, very good for *chapati*. It matures in 105-110 days.

HD 2643 (Ganga)

Year of release : 1997 (CVRC)

Recommended areas : Eastern U.P., Bihar, Jharkhand, Orissa, Sikkim, West Bengal, Assam and plains of NE states

Production conditions : Late sown irrigated

Average yield : 3.7 t/ha

Characteristics : 82 cm in height and matures in 105-110 days, tolerant to brown rust and leaf blight, which are the major diseases of the area. It is also resistant to new virulence of yellow rust, *Yr9*.

HP 1731 (Rajlaxmi)

Year of release : 1995 (CVRC)

Recommended areas : Eastern U.P., Bihar, Jharkhand, Orissa, Sikkim, West Bengal, Assam and plains of NE states

Production conditions : Timely sown irrigated

Average yield : 4.0 t/ha

Characteristics : Resistant to brown and yellow rusts, and tolerant to leaf blight. Good for *chapati*. It matures in 120-125 days.

HP 1633 (Sonali)

Year of release : 1992 (CVRC)

Recommended areas : Eastern U. P., Bihar, Jharkhand, Orissa, Sikkim, West Bengal, Assam and plains of NE states

Production conditions : Late sown irrigated

Average yield : 3.5 t/ha

Characteristics : Resistant to leaf rust, Karnal bunt and tolerant to leaf blight. It matures in 105-110 days.

Central Zone

HI 8638 (Malavkranti)

Year of release : 2009 (CVRC)

Recommended areas : M.P., Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of U.P.

Production conditions : Early sown, rainfed and restricted irrigation

Average yield : 2.5-3.0 t/ha

Characteristics : Good for *suji* and *dalia* making, resistant to brown and black rusts. It matures in 120-125 days.

HI 1544 (Purna)

Year of release : 2007 (CVRC)

Recommended areas : M.P., Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of U.P.

Production conditions : Timely sown irrigated

Average yield : 5.0-5.5 t/ha

Characteristics : Good for *chapati,* resistant to brown and stem rusts. It matures in 110-115 days.

HD 2932 (Pusa Wheat 111)

Year of release : 2007 (CVRC)

Recommended areas : M.P., Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan, Jhansi division of U.P., Maharashtra, Karnataka, A.P., Goa and plains of Tamil Nadu

Production conditions : Late sown irrigated

Average yield : 4.5-5.0 t/ha

Characteristics : It has adult plant resistance against brown and yellow rusts; It also has high zinc content and wider adaptability. It matures in 105-110 days.

HI 1531 (Harshita)

Year of release : 2006 (CVRC)

Recommended areas : M.P., Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of U.P.

Production conditions : Early sown, rainfed and restricted irrigation

Average yield : 2.5-4.0 t/ha

Characteristics : Good for *chapati* making, resistant to brown and black rusts. It matures in 130-135 days.

HI 8627 (Malavkirti)

Year of release : 2005 (CVRC)

Recommended areas : M.P., Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of U.P.

Production conditions : Early sown, rainfed and restricted irrigation

Average yield : 2.0-4.5 t/ha

Characteristics : High quality, high vitamin A, good for *suji* and *dalia* making, resistant to brown and black rusts. It matures in 130-135 days.

HD 2864 (Urja)

Year of release : 2004 (CVRC)

Recommended areas : Gujarat, Madhya Pradesh, Chhattisgarh, Jhansi division of U.P. and Kota and Udaipur divisions of Rajasthan

Production conditions : Late sown irrigated

Average yield : 4.2 t/ha

Characteristics : Highly resistant to brown rust and foot rot and tolerant to black rust.

HI 1500 (Amrita)

Year of release : 2003 (CVRC)

Recommended areas : M.P., Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of U.P.

Production conditions : Timely sown rainfed

Average yield : 2.0-3.0 t/ha

Characteristics : Good for *chapati* making, resistant to brown and stem rusts. It matures in 120-125 days.

HI 1479 (Swarna)

Year of release : 2002 (CVRC)

Recommended areas : M.P., Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of U.P.

Production conditions : Timely sown irrigated

Average yield : 4.5-5.0 t/ha

Characteristics : Good quality for *chapati* making, resistant to brown and stem rusts. It matures in 110-115 days.

HD 4672 (Malavratn)

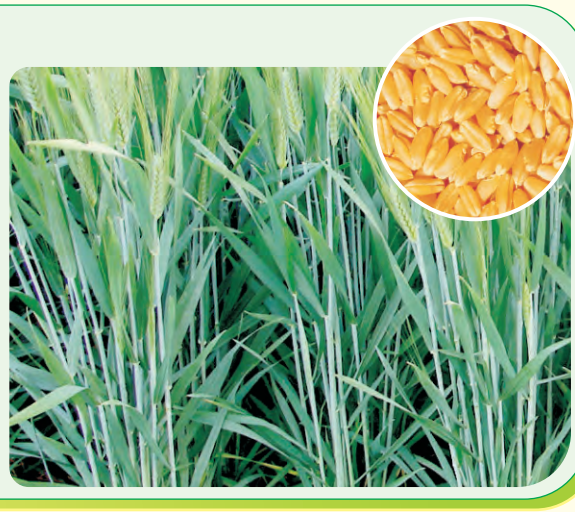
Year of release : 2000 (CVRC)

Recommended areas : M.P., Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of U.P.

Production conditions : Early sown rainfed

Average yield : 2.0-3.5 t/ha

Characteristics : High quality for preparation of *suji* and *dalia*, resistant to brown and stem rusts. It matures in 120-125 days.



HI 1454 (Aabha)

Year of release : 1999 (CVRC)

Recommended areas : Central Zone

Production conditions : Late sown irrigated

Average yield : 4.0-4.5 t/ha

Characteristics : Good for *chapati* making, resistant to brown and black rusts. It matures in 105-110 days.

HI 8498 (Malavshakti)

Year of release : 1999 (CVRC)

Recommended areas : M.P., Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of U.P.

Production conditions : Timely sown irrigated

Average yield : 5.0-6.0 t/ha

Characteristics : Good quality for *suji* and *dalia*, resistant to brown and stem rusts. It matures in 120-125 days.

HI 1418 (Naveen Chandausi)

Year of release : 1999 (CVRC)

Recommended areas : M.P., Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of U.P.

Production conditions : Late sown irrigated

Average yield : 4.5-5.0 t/ha

Characteristics : Good for *chapati* making, resistant to brown and black rusts. It matures in 115-120 days.

HW 2004 (Amar)

Year of release : 1997 (CVRC)

Recommended areas : M.P., Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of U.P.

Production conditions : Timely sown rainfed

Average yield : 1.5-3.0 t/ha

Characteristics : Good for *chapati* making, resistant to brown and stem rusts. It matures in 130-135 days.

DL 788-2 (Vidisha)

Year of release : 1997 (CVRC)

Recommended areas : M.P., Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of U.P.

Production conditions : Late sown irrigated

Average yield : 4.0-4.5 t/ha

Characteristics : Good for *chapati* making, resistant to brown and black rusts. It matures in 110-115 days.

HI 8381 (Malavshri)

Year of release : 1994 (CVRC)

Recommended areas : M.P., Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of U.P.

Production conditions : Timely sown irrigated

Average yield : 5.0-6.0 t/ha

Characteristics : Good quality for preparation of *suji* and *dalia*, resistant to brown and stem rusts. It matures in 125-130 days.

Peninsular Zone

HD 2987 (Pusa Bahar)

Year of release : 2010 (CVRC)

Recommended areas : Maharashtra, Karnataka, A.P., Goa and plains of Tamil Nadu

Production conditions : Timely sown rainfed and restricted irrigation

Average yield : Rainfed- 2.0-2.2 t/ha, limited irrigation-3.0-3.2 t/ha.

Characteristics : Suitable for bread making.

HI 8663 (Poshan)

Year of release : 2007 (CVRC)

Recommended areas : Maharashtra, Karnataka, A.P., Goa and plains of Tamil Nadu

Production conditions : Timely sown irrigated

Average yield : 5.0-5.5 t/ha

Characteristics : Good for *dalia, suji* and *pasta* making, resistant to brown and black rusts. It matures in 120-125 days.

HD 2833 (Pusa Tripti)

Year of release : 2006 (CVRC)

Recommended areas : Maharashtra, Karnataka, A.P., Goa and plains of Tamil Nadu

Production conditions : Late sown irrigated

Average yield : 3.89 t/ha

Characteristics : High degree of adult plant resistance to leaf and stem rusts; a product specific variety possessing >8/10 score for *chapati* making.

HD 2781 (Aditya)

Year of release : 1997 (CVRC)

Recommended areas : Maharashtra, Karnataka, Andhra Pradesh and plains of Tamil Nadu

Production conditions : Timely sown rainfed

Average yield : 2.1 t/ha

Characteristics : Tolerant to black and brown rusts and foot rot. It is suitable for bread making.

Southern Hills Zone

HW 5207 (Pusa Navagiri)

Year of release : 2010 (CVRC)

Recommended areas : Hilly areas of Tamil Nadu and Kerala

Production conditions : Timely sown irrigated

Average yield : 5.21 t/ha

Characteristics : It has high degree of resistance to stem, leaf and stripe rusts. It matures in 105 days.

Northern Hills Zone

HS 507 (Pusa Suketi)

Year of release : 2010 (CVRC)

Recommended areas : Hilly regions of J&K, H.P., Uttarakhand, Sikkim, West Bengal and NE states

Production conditions : Timely sown rainfed as well as irrigated conditions

Average yield : Rainfed - 2.67 t/ha (yield potential 5.43 t/ha) Irrigated - 4.68 t/ha (yield potential 6.01 t/ha)

Characteristics : Only genotype in the country with resistance against all the pathotypes of all the three rusts. It combines very high adult plant resistance against leaf and stripe rusts along with good resistance against leaf blight and Karnal bunt. Good for *chapati* and bread quality.

HS 490 (Pusa Baker)

Year of release : 2009 (CVRC)

Recommended areas : Hilly regions of J&K, H.P., Uttarakhand, Sikkim, West Bengal and NE states

Production conditions : Late sown restricted irrigation

Average yield : 3.10 t/ha (yield potential 4.18 t/ha)

Characteristics : Resistant to yellow, brown and black rusts; best for biscuit making with spread factor of 10.13 and grain hardness value of 33. It matures in 150 days.

HS 375 (Himgiri)

Year of release : 2003 (CVRC)

Recommended areas : Hilly regions of J&K, H.P., Uttarakhand, Sikkim, West Bengal and NE states

Production conditions : Timely (summer) sown conditions of very high altitude

Average yield : 2.62 t/ha (yield potential 4.98 t/ha)

Characteristics : Early maturity with golden grains, resistant to leaf and yellow rusts and hill bunt. It matures in 115 days.

HS 420 (Shivalik)

Year of release : 2003 (CVRC)

Recommended areas : Hilly regions of J&K, H.P., Uttarakhand, Sikkim, West Bengal and NE states

Production conditions : Late sown restricted irrigation

Average yield : 2.67 t/ha (yield potential 4.5 t/ha)

Characteristics : Highly resistant to yellow and brown rusts. It matures in 149 days.

HS 365

Year of release : 1998 (CVRC)

Recommended areas : Hilly regions of J&K, H.P., Uttarakhand, Sikkim, West Bengal and NE states

Production conditions : Timely sown rainfed and low fertility areas of high altitude

Average yield : 1.82 t/ha (yield potential 2.7 t /ha)

Characteristics : Early maturity, bold seeded and easy threshibility. It matures in 185 days.

HS 277

Year of release : 1992 (CVRC)

Recommended areas : Hilly regions of J&K, H.P., Uttarakhand, Sikkim, West Bengal and NE states

Production conditions : Early sown rainfed

Average yield : 2.58 t/ha

Characteristics : Resistant to yellow and brown rusts, loose smut and hill bunt. It matures in 210 days.

HS 295

Year of release : 1992 (CVRC)

Recommended areas : Hilly regions of J&K, H.P., Uttarakhand Sikkim, West Bengal and NE states

Production conditions : Late sown restricted irrigation

Average yield : 2.61 t/ha

Characteristics : Resistant to yellow and brown rusts and hill bunt. It matures in 145 days.

Barley

BHS 380 (Pusa Losar)

Year of release : 2010 (CVRC)

Recommended areas : Hilly regions of J&K, H.P., Uttarakhand, Sikkim, West Bengal and NE states

Production conditions : Timely sown rainfed areas of mid-hills

Average yield : 2.54 t/ha

Characteristics : Resistant to blight and all three rusts. It matures in 182 days.

BHS 352 (Himadri)

Year of release : 2003 (CVRC)

Recommended areas : Hilly regions of J&K, H.P., Uttarakhand, Sikkim, West Bengal and NE states

Production conditions : Timely sown rainfed and low fertility areas

Average yield : 2.2 t/ha (yield potential 3.9 t/ha)

Characteristics : Huskless; tolerant to yellow rust. It matures in 173 days.

Recommended cultivation practices for wheat and barley*

Agronomic practices	Irrigated timely sown	Irrigated late sown	Rainfed timely sown
Seed rate (kg/ha)	100	125	125
Time of sowing	5-25 November	25 November-25 December	25 October-15 November
Fertilizers (N:P:K kg/ha) and time of application	120:50:40 (Half quantity of N and full doses of P&K as basal dose and the rest half of N after Ist irrigation)	80:40:40 (Half quantity of N and full doses of P&K as basal dose and the rest half of N after Ist irrigation)	60:40:20 (for wheat) 40:20:20 (for barley) (Full quantity of NPK as basal dose)
Irrigation	Ist irrigation after 21 days of sowing and the rest according to needs	Ist irrigation after 21 days of sowing and the rest according to needs	If possible, Ist irrigation after 30 days of sowing
Weed control	Leader @ 33 g/ha, Topic @ 400 g/ha after 27-35 days of sowing	Leader @ 33 g/ha, Topic @ 400 g/ha after 27-35 days of sowing	–
Disease control	Seed treatment with Carbendazim @ 2.5 g/kg of seeds for control of smut	Seed treatment with Carbendazim @ 2.5 g/kg of seeds for control of smut	Seed treatment with Carbendazim @ 2.5 g/kg of seeds for control of smut
Insect control	Spray of Imidacloprid (20 g a.i./ha) or Quinalphos 25 E.C. (250-480 g/ha) for control of leaf and stem cutting insects	Spray of Imidacloprid (20 g a.i./ha) or Quinalphos 25 E.C. (250-480 g/ha) for control of leaf and stem cutting insects	Spray of Imidacloprid (20 g a.i./ha) or Quinalphos 25 E.C. (250-480 g/ha) for control of leaf and stem cutting insects

*Barley only under rainfed condition

Rice

During the year 2010-11, rice crop was cultivated in an area of 42.56 million hectares in India with a production of 95.98 million tonnes. The productivity of rice is 2.24 t/ha, which can be enhanced through the use of improved varieties and appropriate agronomic practices. The IARI has made a remarkable contribution in developing high yielding *basmati* rice varieties, which helped in increasing rice export. The details of the improved rice varieties developed at IARI are given below:

Fine grain aromatic (*basmati)* rice varieties

Pusa Basmati 6 (Pusa 1401)

Year of release : 2008 (CVRC)

Recommended areas : Punjab, Haryana, western Uttar Pradesh and Uttarakhand

Production conditions : Irrigated and transplanted

Average yield : 5.0-5.5 t/ha

Characteristics : It has a semi- dwarf plant stature and therefore, tolerant to lodging. Pusa 1401 has a significant improvement over Pusa Basmati 1121; its grains on cooking have uniform shape as against the tapering end in Pusa Basmati 1121. It has a strong aroma and less than 4% chalky grains. It matures in 150-155 days.

Improved Pusa Basmati 1 (Pusa 1460)

Year of release : 2007 (CVRC)

Recommended areas : Punjab, Haryana, western Uttar Pradesh and Uttarakhand

Production conditions : Irrigated and transplanted

Average yield : 5.5-6.0 t/ ha

Characteristics : It was developed by incorporating resistance to bacterial leaf blight by pyramiding genes Xa13 and Xa21 in Pusa Basmati 1 through marker assisted back cross breeding method while retaining the agronomic features of Pusa Basmati 1. It matures in 135-140 days. Cooking quality is superior and it has less than 10% chalky grains.

Pusa Sugandh 5 (Pusa 2511)

Year of release : 2005 (CVRC)

Recommended areas : Delhi, Punjab, Haryana, western Uttar Pradesh, and Jammu & Kashmir.

Production conditions : Irrigated and transplanted

Average yield : 5.5-6.0 t/ha

Characteristics : A semi-dwarf high yielding aromatic rice variety suitable for multiple cropping system in northern India. It has extra long grains and excellent cooking quality. It possesses tolerance to shattering. It is resistant to gall midge, brown spot and moderately resistant to leaf folder and blast disease. It matures in 120-125 days.

Pusa Basmati 1121

Year of release : 2003 (SVRC, Delhi)

Recommended areas : Punjab, Haryana, western Uttar Pradesh, and Uttarakhand and all other Basmati grawing areas

Production conditions : Irrigated and transplanted

Average yield : 4.0-4.5 t/ha

Characteristics : It matures in 140-145 days, a fortnight earlier than *Taraori basmati*. The grain is longer (8 mm) with cooked grain length of approximately 20 mm and it is better in cooking compared to that of *Taraori basmati*. It requires low input and produces high yield with better quality rice for export.

Pusa RH 10 (Hybrid)

Year of release : 2001 (CVRC)

Recommended areas : Punjab, Haryana, Delhi, western Uttar Pradesh and Uttarakhand

Production conditions : Irrigated and transplanted

Average yield : 6.5 t/ha

Characteristics : World's first superfine grain aromatic rice hybrid possessing typical *basmati* quality traits. Strongly scented, long slender grains with almost twice kernel elongation on cooking. It matures in 110-115 days, hence, saves irrigation water. It has high per day productivity and is well suited for rice-wheat cropping system in northern India.

Pusa Sugandh 3

Year of release : 2001 (CVRC)

Recommended areas : Punjab, Haryana, Delhi, western Uttar Pradesh and Uttarakhand

Production conditions : Irrigated and very suitable for multiple cropping systems, viz., rice-vegetables (spinach/radish/potato)-wheat-mungbean.

Average yield : 6.0 t/ha

Characteristics : Semi-dwarf high yielding rice variety, possessing strong aroma, extra-long slender grains and with almost twice elongation on cooking and pleasant taste. It matures in 125 days.

Pusa Sugandh 2

Year of release : 2001 (CVRC)

Recommended areas : Punjab, Haryana, Delhi, western Uttar Pradesh and Uttarakhand

Production conditions : Irrigated and transplanted

Average yield : 5.5 t/ha

Characteristics : A semi-dwarf high yielding aromatic rice variety possessing *basmati* grain quality traits. It has extra-long slender grains with strong aroma; almost twice elongation on cooking, soft texture, good mouth feel and appealing taste. It matures in 120-125 days and is fit for multiple cropping.

Pusa Basmati 1

Year of release : 1989 (CVRC)

Recommended areas : Punjab, Haryana, western Uttar Pradesh and Uttarakhand

Production conditions : Irrigated

Average yield : 5.0-5.5 t/ha

Characteristics : It is the first semi-dwarf, high yielding *basmati* rice variety. It possesses excellent grain and cooking quality with soft texture and pleasant aroma. Contributes approximately 50 per cent of the total *basmati* export from India. Well suited for rice-wheat cropping system in northern India. It matures in 130-135 days.

Non-aromatic Rice varieties

Pusa 44

Year of release : 1994 (CVRC)

Recommended areas : Karnataka, Kerala, Punjab, Haryana and Uttar Pradesh

Production conditions : Irrigated and transplanted

Average yield : 7.0-8.0 t/ha

Characteristics : It is a dwarf variety, which matures in about 140-145 days. Its grains are long, slender and translucent. Good head rice recovery during milling. This is a very appropriate variety for combine harvesting because of sturdy stem and non-lodging habit.

Recommended cultivation practices

Seed rate: *Basmati* and long slender grain varieties-16-20 kg/ha; **Spacing:** transplantation, row to row -20 cm and plant to plant-15 cm; **Appropriate time of sowing :** 15 May to 15 June; **Time of transplanting:** 25-30 days after sowing of seeds in nursery; **Fertilizers (NPK, kg/ha):** 80-50-40. Apply one third of Nitrogen and full quantity of other fertilizers before planting as basal doses and 50% of the rest of N at 5 days after planting and 50% at the time of tillering (after 50-60 days); **Irrigation:** Keep standing water of 5-6 cm up to 2-3 weeks after transplanting; later on irrigation can be done as per needs, but soil should be saturated with moisture. Irrigation is must at the time of flowering; **Weed control :** Spray of 2.5-3.0 litres Butachlor 50 EC solution in 500-600 litres of water/ha after 3-5 days of planting; **Disease control:** Spray the solution of 500 g of Carbendazim in 500 liters of water/ha for contol of sheath blight and blast diseases; **Insect control:** Spray the solution of Monocrotophos 36 SL@1.4 litres/ha in 500-600 liters of water for stem borer and leaf folder. Spray 200 ml Confidor/ha in 500-600 litres of water for control of brown plant hopper.

Coarse Cereals

During the year 2010-11, the coarse cereal crops were cultivated in an area of 27.64 million hectares with a production of 43.68 million tonnes. The productivity of coarse cereals is only 1.52 tonnes/ hectare, which is much less than the productivity obtained in research farms. The yield level of coarse cereals can be enhanced through adoption of improved varieties and appropriate agronomic practices.

Maize

During the year 2010-11, maize was cultivated in an area of 8.49 million hectares in India with a production of 21.28 million tonnes of grains. The productivity of this crop is 2.50 tonnes/hectare, which could be enhanced by appropriate agronomic practices. It is also cultivated as baby corn, sweet corn, pop corn and green cobs for enhancing the farmers' income. Details of the improved maize varieties developed at IARI are given below:

Normal sowing

Pusa Composite 3

Year of release : 2005 (SVRC)

Recommended areas : National Capital Region of Delhi

Production conditions : Irrigated and rainfed

Average yield : 4.4 t/ha

Characteristics : It is composite variety and has medium maturity, stay-green character and long ears with yellow-orange flint grains. It is tolerant to major foliar diseases and stem borer and resistant to lodging. It matures in 85-90 days.

Pusa Composite 4

Year of release : 2005 (SVRC)

Recommended areas : National Capital Region of Delhi

Production conditions : Irrigated

Average yield : 4.5 t/ha

Characteristics : Belongs to medium maturity group with moderate stature. It has stay green character with long ears and yellow flint grains. Tolerant to major foliar diseases and stem borer and resistant to lodging. Its performance is good in low input and biotic stress conditions. It matures in 85-90 days.

Hybrid AH 421 (PEHM 5)

Year of release : 2004 (CVRC)

Recommended areas : Punjab, Haryana, Rajasthan, Delhi, Uttar Pradesh, J&K, H.P., Uttarakhand, A.P., Karnataka, Maharashtra and Tamil Nadu

Production conditions : Normal sowing and water logged

Average yield : 5.0-6.0 t/ha (seed yield)

Characteristics : An early (78-82 days) maturing single cross hybrid; suitable for water logged conditions and shows good response to high nitrogen levels.

Hybrid AH 58 (PEHM 3)

Year of release : 2001 (CVRC)

Recommended areas : A.P., Karnataka, Maharashtra, Tamil Nadu and National Capital Region of Delhi

Production conditions : Normal sowing

Average yield : 5.0 t/ha (seed yield)

Characteristics : An early maturing (78-82 days) single cross hybrid with attractive and yellow flint bold seeds. It is tolerant to high temperature and lodging.

Recommended cultivation practices

Seed rate: 20 kg/ha; **Spacing:** Row to row 60-75 cm and plant to plant 18-20 cm; **Time of sowing :** 15 June - 15 July; **Fertilizers (NPK&Zn, kg/ha):**100-60-40-25. Apply one fourth of nitrogen and full quantity of other fertilizers as basal doses, 50% dose of remaining nitrogen at 20-30 days after germination and the rest at the time of flowering as top dressing; **Irrigation:** Irrigation in the absence of rainfall is necessary especially at flowering and grain formation stages; **Weed control :** Spray the solution of 1.0-1.5 litres Atrazine in 800 litres of water/ha after sowing but before germination; **Disease control:** Spray the solution of 2.5 kg Zineb in 1000 liters of water /ha for control of downy mildew and maydis diseases; **Insect control:** Spray the solution of Carbaryl (85% W.P.) 2.35 g/litre of water for control of stem borer.

Pearl Millet (*Bajra*)

During the year 2010-11, *bajra* was cultivated in an area of 9.43 million hectares in India with a production of 10.08 million tonnes. The productivity of this crop is 1069 kilograms per hectare, which can be enhanced by the use of quality seeds of improved varieties and appropriate agronomic practices. It is also grown as green fodder for animals. Details of improved varieties of pearl millet developed at IARI are given below:

Pusa Composite 612

Year of release : 2008 (CVRC)

Recommended areas : Maharashtra, Tamil Nadu, Karnataka and Andhra Pradesh

Production conditions : Rainfed and irrigated

Average yield : 2.5 t/ha

Characteristics : Dual purpose variety, which can be grown both for fodder and grains. It matures in 80-85 days and is resistant to downy mildew disease in natural conditions. It is suitable for normal and late sowing conditions.

Pusa Composite 443

Year of release : 2008 (CVRC)

Recommended areas : Rajasthan, Gujarat and Haryana

Production conditions : Rainfed

Average yield : 1.8 t/ha

Characteristics : An early maturing variety, which possesses resistance to downy mildew. This composite variety is suitable for cultivation in areas where the rainfall is less than 400 mm.

Pusa Composite 383

Year of release : 2001 (CVRC)

Recommended areas : Rajasthan, Gujarat, Haryana, Madhya Pradesh, Uttar Pradesh, Punjab and Delhi

Production conditions : Rainfed and irrigated

Average yield : 2.2-2.4 t/ha

Characteristics : Dual purpose variety, which can be used both for grain and fodder. Farmers can use their own produce as seed with a minimum training. The stalks are good for fodder.

Pusa Hybrid 415

Year of release : 1999 (CVRC)

Recommended areas : Rajasthan, Gujarat, Haryana, Madhya Pradesh, Uttar Pradesh, Punjab and Delhi

Production conditions : Irrigated and rainfed

Average yield : 2.3-2.5 t/ha

Characteristics : It matures in 75-78 days and possesses resistance to downy mildew and tolerance to moisture stress.

Pusa Hybrid 605

Year of release : 1999 (CVRC)

Recommended areas : Rajasthan, Gujarat, Haryana, Madhya Pradesh, Uttar Pradesh, Punjab and Delhi

Production conditions : Irrigated and rainfed

Average yield : 2.2-2.4 t/ha

Characteristics : It matures in 74-80 days. It is resistant to downy mildew. Performs well in irrigated as well as rainfed areas.

Recommended cultivation practices

Seed rate: 4-5 kg/ha; **Spacing:** Row to row 45-50 cm and plant to plant 8-10 cm; **Appropriate time of sowing:** After onset of monsoon or July month; **Fertilizers (NPK, kg/ha):** 60-30-30 (rainfed), 80-40-40 (irrigated), apply half of nitrogen and full quantity of other fertilizers as basal dose and the rest half dose of nitrogen as top dressing after 4-5 weeks after germination; **Irrigation:** 2-3 irrigations if rainfall is not available; **Weed control:** Spray the solution of 0.5 kg Atrazine (A. I.) in 800 litres water/ha after sowing but before germination; **Disease control:** Spray Ridomil M Z -72 @ 2.5 gram/litre of water for control of downy mildew and Bavistin @1g/litre of water for ergot disease; **Insect control:** Spray the solution of Carbaryl (85% W.P.) 2.35 g/litre of water for control of hairy caterpillar, brown beetle and grasshopper.

Pulse Crops

During the year 2010-11, pulse crops were cultivated in an area of 26.28 million hectares in India with a production of 18.24 million tonnes. The recorded average yield of pulse crops is only 689 kilograms per hectare, which can be increased through the adoption of quality seeds of improved varieties and appropriate agronomic practices.

Chickpea (Gram)

During the year 2010-11, the area under chickpea cultivation was 9.21 million hectares in India with a production of 8.25 million tonnes and a productivity of 896 kilograms per hectare. The improved varieties of chickpea which can increase the productivity are given below:

Northern India

Pusa 547 (*Desi*)

Year of release	:	2006 (CVRC)
Recommended areas	:	Delhi, Haryana, Punjab, U.P. and Rajasthan
Production conditions	:	Late sown irrigated
Average yield	:	1.8-2.5 t/ha
Characteristics	:	It is of medium maturity (135 days), tolerant to wilt, root rot and stunt diseases and fruit borer.

Pusa Chamatkar (BG 1053) (*Kabuli*)

Year of release : 1999 (CVRC)

Recommended areas : Delhi, Haryana, Punjab, Rajasthan and U.P.

Production conditions : Irrigated

Average yield : 2.5-3.0 t/ha

Characteristics : Resistant to soil borne diseases; bold seeded; good cooking quality. It matures in 145-150 days.

Pusa 362 *(Desi)*

Year of release : 1994 (CVRC)

Recommended areas : North India

Production conditions : Normal and late sowing

Average yield : 2.5-3.0 t/ha

Characteristics : It is resistant to soil borne diseases, tolerant to drought and very good for cooking; Grains are very good with yellowish brown colour. It matures in 155 days.

Pusa 372 (*Desi*)

Year of release : 1993 (CVRC)

Recommended areas : Delhi, Haryana, Punjab, Rajasthan, U.P., Bihar, M.P., Gujarat and Maharashtra

Production conditions : Late sown, irrigated and rainfed

Average yield : Late sown - 1.8-2.2 t/ha
Normal - 2.5-3.0 t/ha

Characteristics : Resistant to soil borne diseases; good for *dal* and *besan* making; very wide adaptability and drought tolerant. It matures in 140-145 days.

Central India

Pusa Subhra (BGD 128)

Year of release : 2006 (CVRC)

Recommended areas : M.P., Maharashtra, Gujarat, Bundelkhand parts of U.P. and adjoining parts of Rajasthan

Production conditions : Irrigated and late sown

Average yield : 1.7-2.3 t/ha

Characteristics : Moderately resistant to soil borne diseases and stunt. Owing to its semi-erect growth habit, it is suitable for mechanical harvesting. It matures in 110-115 days.

Pusa Dharwar Pragati (BGD 72)

Year of release : 1999 (CVRC)

Recommended areas : M.P., Maharashtra, Gujarat, Bundelkhand, parts of U.P. and adjoining parts of Rajasthan

Production conditions : Rainfed

Average yield : 2.2-2.8 t/ha

Characteristics : Moderately resistant to soil borne diseases and resistant to drought. Bold seeded and matures in 115-120 days.

National Capital Region

Pusa 2024 *(Kabuli)*

Year of release : 2008 (SVRC)

Recommended areas : National Capital Region of Delhi

Production conditions : Irrigated and rainfed

Average yield : 2.5-2.8 t/ha

Characteristics : Moderately resistant against soil borne diseases and drought. It matures in 145 days.

Pusa 1108 *(Kabuli)*

Year of release : 2006 (SVRC)

Recommended areas : National Capital Region of Delhi

Production conditions : Timely sown irrigated

Average yield : 2.5-3.0 t/ha

Characteristics : Resistant to soil borne diseases. Having bold, uniform, creamy coloured, attractive grains with excellent cooking quality, the variety fetches high market prices. It matures in 145-150 days.

Pusa 1105 *(Kabuli)*

Year of release : 2005 (SVRC)

Recommended areas : National Capital Region of Delhi and Karnataka

Production conditions : Irrigated under normal sowing

Average yield : 2.5-3.0 t/ha

Characteristics : Bold seeded (30 g/100 seeds), moderately resistant against soil borne diseases and highly tolerant against drought. It matures in 145 days in north India and 120 days in south India.

Pusa 1103 *(Desi)*

Year of release : 2005 (SVRC)

Recommended areas : National Capital Region of Delhi

Production conditions : Late sown

Average yield : 2.0-2.4 t/ha

Characteristics : First variety developed by using a wild species (*C. reticulatum*). It possesses resistance against wilt/root rot, drought and high temperature. Suitable for rice based cropping system in northern India. It matures in 130-140 days.

Pusa 1088 (*Kabuli*)

Year of release : 2004 (SVRC)

Recommended areas : National Capital Region of Delhi

Production conditions : Rainfed and irrigated

Average yield : 2.0-3.0 t/ha

Characteristics : It is resistant to soil bore disease like *Fusarium* wilt, root rot and stunt virus drought. Bold seeded and matures in 135-140 days.

Recommended cultivation practices

Seed rate: Irrigated - 60 kg/ha (small seeded), 80 kg/ha (bold seeded); Rainfed - 75 kg/ha(small seeded), 100 kg/ha (bold seeded); **Spacing:** Row to row 30-45 cm; **Depth of sowing:**10 cm; **Appropriate time of sowing :** Mid October to first week of November; **Fertilizers (NPS&Zn, kg/ha):** 20-50-20-25 as basal dose; **Irrigation:** Two irrigations after 45 and 75 days of sowing; **Weed control:** Spray the solution of 1.0 kg Pendimethalin in 600-700 litres water/ha after sowing but before germination; **Disease control:** Seed treatment by Captan @ 2.0 g/kg seed. **Insect control:** Spray of HaNPV @ 250 L.E./500 litres of water / ha or Monocrotophos (30 S.L.) @ 250 g a.i. in 500 litres of water/ha for control of pod borer.

Fieldpea

Pusa Prabhat (DDR 23)

Year of release : 2001 (CVRC)

Recommended areas : U.P., Bihar, West Bengal and Assam

Production conditions : Irrigated and rainfed

Average yield : 1.5 t/ha

Characteristics : It is a dwarf, extra early maturing (average 102 days) and powdery mildew resistant variety.

Pusa Panna (DDR 27)

Year of release : 2001 (CVRC)

Recommended areas : Western Uttar Pradesh, Haryana, Punjab, Rajasthan and Uttarakhand

Production conditions : Irrigated and rainfed

Average yield : 1.7 t/ha

Characteristics : It is a dwarf, extra-early (90 days) and powdery mildew resistant variety.

Recommended cultivation practices

Seed rate : 80-100 kg/ha; **Spacing:** Row to row 30 cm (dwarf varieties 15-20 cm), plant to plant 5 cm; **Appropriate time of sowing:** Last week of October to mid November; **Fertilizers (NPS&Zn, kg/ha):** 30-40-30-25 as basal dose; **Irrigation:** Two irrigations after 45 and 75 days of sowing; **Weed control:** Spray the solution of 0.75-1.0 kg Pendimethalin in 800-1000 litres of water/ha after sowing but before germination; **Disease control:** Spray the solution of Sulfex or Alosol @ 3.0 kg/ha in 800-1000 litres of water for control of powdery mildew and seed treatment by Bavistin or Thiram @ 3.0 g/kg seed for control of wilt; **Insect control:** Spray Malathion (50 EC) 750 g a.i./ha for control of pod borer and Metasystox 20 EC @ 1.0 litre/ha for leaf miner in 600-800 litres of water.

Lentil

Pusa Lentil 5 (L 4594)

Year of release : 2006 (SVRC)

Recommended areas : National Capital Region of Delhi

Production conditions : Irrigated and rainfed

Average yield : 1.7 t/ha

Characteristics : It has medium growth habit, small seeded, orange cotyledon and resistance to rust. It matures in 125-135 days.

Pusa Vaibhav (L 4147)

Year of release : 1997 (CVRC)

Recommended areas : Western Uttar Pradesh, Haryana, Punjab, Rajasthan, Uttarakhand, parts of Rajasthan and Himachal Pradesh

Production conditions : Irrigated and rainfed

Average yield : 1.7 t/ha

Characteristics : The seeds are small with orange cotyledons. It is resistant to wilt and rust and matures in 120-125 days.

Pusa Shivalik (L 4076)

Year of release : 1995 (CVRC)

Recommended areas : Western Uttar Pradesh, Haryana, Punjab, Uttarakhand, parts of Rajasthan and Himachal Pradesh

Production conditions : Irrigated and rainfed

Average yield : 1.5 t/ha

Characteristics : It is resistant to wilt and rust and matures in 120-125 days.

Recommended cultivation practices

Seed rate: 35-40 kg/ha (small seeded), 50-60 kg/ha (bold seeded); **Spacing:** Row to row 25-35 cm, plant to plant 1-2 cm; **Appropriate time of sowing:** Last week of October to mid November; **Fertilizers (NPK, S&Zn, kg/ha):** 20-50-40-30-25 as basal dose; **Irrigation:** Two irrigations after 40-45 and 70-80 days of sowing; **Disease control:** Two sprays of the solution of Sulfex @ 0.3 % for control of white powdery mildew and seed treatment by Thiram @ 3.0 g/kg seed for control of wilt; **Insect control:** Spray Imidacloprid (17.8%) 20-25 g a.i./ha in 500 litres of water for control of aphids.

Pigeonpea *(Arhar)*

During the year 2010-11, pigeonpea was cultivated in an area of 4.42 million hectares in India with a production of 2.89 million tonnes. The recorded productivity of pigeonpea is only 655 kilograms per hectare, which can be enhanced through improved varieties and agronomic practices. The improved varieties of pigeonpea developed by IARI are given below:

Pusa 2002

Year of release : 2008 (SVRC)
Recommended areas : National Capital Region of Delhi
Production conditions : Timely sown (*kharif* season)
Average yield : 1.77 t/ ha
Characteristics : This variety can fit well in the double cropping system. A timely sown crop can be harvested by the second week of November, thus leaving the field for *rabi* crops. It matures in 140-145 days.

Pusa 2001

Year of release : 2006 (SVRC)
Recommended areas : National Capital Region of Delhi
Production conditions : Timely sown (*kharif* season)
Average yield : 2.0 t/ ha
Characteristics : High yielding variety and suitable for *arhar*-wheat rotation. It matures in 140-145 days.

Pusa 992

Year of release	:	2005 (CVRC)
Recommended areas	:	Haryana, Punjab, Rajasthan, Western Uttar Pradesh and Delhi.
Production conditions	:	Rainfed
Average yield	:	1.65 t/ha
Characteristics	:	Medium bold seed (8.5g/100 seeds), brown, shining and round. Suited for *arhar* – wheat rotation. It matures in 140-145 days.

Pusa 991

Year of release	:	2005 (SVRC)
Recommended areas	:	National Capital Region of Delhi
Production conditions	:	Rainfed
Average yield	:	1.84 t/ha
Characteristics	:	Highly suitable for rainfed and salinity prone areas. Seed is medium bold (7.9 g/100 seeds), brown, shining and round. It matures in 140-145 days. Suited for *arhar*-wheat rotation.

Pusa 9

Year of release	:	1993 (CVRC)
Recommended areas	:	North-eastern, eastern and central regions
Production conditions	:	*Kharif* and pre-rabi sowings
Average yield	:	2.0-2.5 t/ ha
Characteristics	:	Medium height, suitable for intensive farming, resistant to *Alternaria* blight disease. It matures in 240 days.

Recommended cultivation practices

Seed rate: 10-15 kg/ha; **Spacing:** Row to row 60-75 cm, plant to plant -15 cm; **Time of sowing:** Second week of June or after onset of monsoon; **Fertilizers (NPK, kg/ha):** 20-40-20 as basal dose or 100 kg DAP/ha; **Irrigation:** Two irrigations during pre sown and pod formation stages; **Disease control:** Sowing on bunds after the seed is treated by Bavistin or Ridomil MZ-72 @ 2.5 g/kg seed for control of wilt and Phytopthora blight; **Insect control:** Spray Monocrotophos 36 WSC @ 1 ml/ litre of water for control of pod borer and blister beetle and Indoxacarb @ 1 ml/litre against *Maruca vitrata,* which is a devastating insect pest.

Mungbean

Pusa 0672

Year of release : 2009 (CVRC)

Recommended areas : Northern hilly region

Production conditions : *Kharif* season

Average yield : 0.95 -1.0 t/ha

Characteristics : Tolerant to yellow mosaic virus. Seeds are of medium size, attractive and green in colour. It matures in 52-103 days.

Pusa Ratna

Year of release : 2005 (SVRC)

Recommended areas : National Capital Region of Delhi

Production conditions : *Kharif* season

Average yield : 1.2 t/ha

Characteristics : It matures in 65-70 days and synchronous in maturity. Tolerant to yellow mosaic virus.

Pusa Vishal

Year of release : 2001 (CVRC)

Recommended areas : Western Uttar Pradesh, Haryana, Punjab, Rajasthan, plains of Himachal Pradesh and J&K

Production conditions : Spring/ summer cultivation

Average yield : 1.2 t/ha

Characteristics : Resistant to mungbean yellow mosaic virus. It matures in 65-70 days in spring and 60-65 days in summer seasons and synchronous in maturity.

Pusa 9531

Year of release : 2001 (CVRC)

Recommended areas : Punjab, Haryana, western Uttar Pradesh, Rajasthan, plains of J&K and Himachal Pradesh

Production conditions : *Kharif* season

Average yield : 1.2 t/ha

Characteristics : It matures in 60-65 days. Pods are light brown in colour at maturity and tolerant to yellow mosaic virus.

Recommended cultivation practices

Seed rate: 15-20 kg/ha; **Spacing:** Row to row - 20-30 cm, plant to plant - 8-10 cm; **Time of sowing :** Mid- March to mid-April (summer) and July (*kharif*); **Fertilizers (NPK, kg/ha):** 20-40-20 as basal dose; **Irrigation:** 3-4 irrigations as per the need; **Weed control:** Spray Basalin 1 litre in 400 litres of water before sowing and mix in soil immediately. Pendimethalin @ 1 kg/ha 1-2 days after sowing of crop, dissolving in 500 litres of water per hectare; **Insect control:** Spray Methyl Demeton 25 EC or Monocrotophos 36 SL @ 1 ml/ litre of water for control of thrips, jassids and white flies.

Oilseed Crops

During the year 2010-11, the area under major oilseed crops was 26.82 million hectares in India with a production of 32.48 million tonnes and productivity of 1159 kilograms per hectare.

Mustard

The area under mustard in India during the year 2010-11, was 6.51 million hectares with a production of 7.67 million tonnes. The per hectare productivity of mustard is only 1179 kilograms, which can be enhanced through the use of improved varieties and agronomic practices. The improved mustard varieties developed by IARI are given below:

National Capital Region

Pusa Tarak (EJ-13)

Year of release : 2009 (SVRC)

Recommended areas : National Capital Region of Delhi

Production conditions : Early (September) sown

Average yield : 1.92 t/ha

Characteristics : This variety is useful for multiple cropping system particularly during the period of September-December. It matures in 121 days and the seeds contain 40% oil.

Pusa Vijay (NPJ-93)

Year of release : 2008 (SVRC)

Recommended areas : National Capital Region of Delhi

Production conditions : Timely sown

Average yield : 2.5 t/ha

Characteristics : It is tolerant to abiotic stresses, viz., high temperature at seedling stage, salinity up to 12 ds/m and lodging. It matures in 145 days and the seeds contain 38.5% oil.

Pusa Mustard 22 (LET -17)

Year of release : 2008 (SVRC)

Recommended areas : National Capital Region of Delhi

Production conditions : Timely sown irrigated

Average yield : 2.07 t/ha

Characteristics : It is a single zero (<2% erusic acid) variety of Indian mustard. Mean 1000 seeds weight of this variety is 3.6 g. It matures in 142 days and the seeds contain 35.5% oil.

Pusa Karishma (LES-39)

Year of release : 2005 (SVRC)

Recommended areas : National Capital Region of Delhi

Production conditions : Timely sown irrigated

Average yield : 2.2 t/ha

Characteristics : It is the first single zero (<2% erusic acid) variety of Indian mustard having attractive yellow seed coat colour. It has tolerance to white rust. It matures in 145 days. It contains 38% oil.

Central India (Zone III)

Pusa Mustard 27 (EJ-17)

Year of release : 2010 (CVRC)

Recommended areas : Uttar Pradesh, Uttarakhand, Chhattisgarh and Kota region of Rajasthan

Production conditions : Early (September) sown irrigated

Average yield : 1.53 t/ha

Characteristics : It is suitable for multiple cropping system. It matures in 118 days and is moderately tolerant to high temperature at seedling as well as at maturity stages. Seeds contain 41.7% oil.

Pusa Jagannath (VSL-5)

Year of release : 1999 (CVRC)

Recommended areas : Uttar Pradesh, Uttarakhand, Madhya Pradesh, Chhattisgarh and Rajasthan

Production conditions : Timely as well as late sown

Average yield : 2.5 t/ha

Characteristics : Medium sized seed (5.5 g/1000 seeds) with 40% oil content. Field tolerance against white rust and *Alternaria* blight under irrigated condition. It matures in 125 days.

North Western Plains Zone (Zone II) and Central India (Zone III)

Pusa Mustard 21 (LES-127)

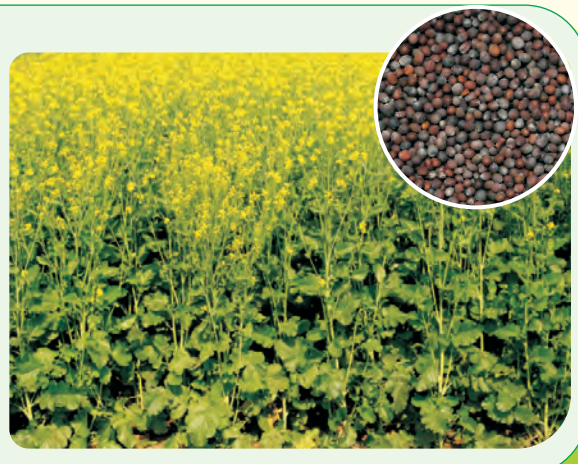
Year of release : 2007 (CVRC)

Recommended areas : Punjab, Haryana, Delhi, Rajasthan, Uttar Pradesh, Uttarakhand, plains of J&K, Madhya Pradesh and Chhattisgarh

Production conditions : Timely sown irrigated

Average yield : Zone II: 2.11 t/ha, Zone III: 1.86 t/ha

Characteristics : A low erusic acid (single zero) variety of Indian mustard. It has a wider adaptability. It matures in 142 days in zone II and 133 days in zone III and the seeds contain 36% oil.



North Western Plains Zone (Zone II)

Pusa Mustard 26 (NPJ-113)

Year of release : 2010 (CVRC)

Recommended areas : Rajasthan, Punjab, Haryana, Delhi, plains of J&K, Himachal Pradesh and western Uttar Pradesh

Production conditions : Late sown irrigated

Average yield : 1.6 t/ha

Characteristics : It is suitable for multiple cropping systems particularly in rice and cotton belts and areas where long duration *guar* varieties are grown. It matures in 126 days and possesses terminal heat tolerance. Seeds contain 37.6% oil.

Pusa Mustard 25 (NPJ-112)

Year of release : 2009 (CVRC)

Recommended areas : Rajasthan, Haryana, Punjab, Delhi, Western Uttar Pradesh, plains of J&K and Himachal Pradesh

Production conditions : Early (First week of September) sown irrigated

Average yield : 1.5 t/ha

Characteristics : It is an early maturing variety, which matures in 107 days. It is suitable for multiple cropping system between September (after harvest of *kharif*) to mid-December (up to sowing of *rabi* crops particularly wheat and vegetables) to have an additional crop. Seeds contain 39.6% oil.

Pusa Mustard 24 (LET-18)

Year of release : 2008 (CVRC)

Recommended areas : Rajasthan, Punjab, Haryana, Delhi, plains of J&K and western Uttar Pradesh

Production conditions : Timely sown irrigated

Average yield : 2.02 t/ha

Characteristics : It is a low erucic acid (<2.0%) variety of Indian mustard. This variety is at par in maturity (140 days) with the conventional mustard varieties. It is a small seeded variety (4.0 g/ 1000 seeds) with 36.55% oil content.

North Western Plains Zone (Zone II) and Eastern Zone (Zone V)

Pusa Mahak (JD-6)

Year of release : 2005 (CVRC)

Recommended areas : Orissa, Jharkhand, Chhattisgarh, Bihar, West Bengal, Assam and National Capital Region of Delhi

Production conditions : Early (September) and late (November) sown irrigated

Average yield : 1.75 t/ha

Characteristics : It is a substitute of *toria.* In north eastern and eastern states, it fits well after rice crop. It is very suitable variety for planting onion or sugarcane as succeeding crop. It matures in 118 days and the seeds contain 40% oil.

Pusa Agrani (SEJ-2)

Year of release : 1998 (CVRC)

Recommended areas : Punjab, Haryana, Rajasthan, Delhi, Bihar, West Bengal, Orissa and Assam

Production conditions : Early (September) and late (November) sown irrigated

Average yield : 1.75 t/ha

Characteristics : The first early maturing (110 days) variety of Indian mustard. It is a substitute of *toria.* In north eastern and eastern states, it fits well after rice crop. Seed is of medium size (4.5 g/1000 seeds) with 39-40 % oil content.

All Over India

Pusa Bold

Year of release : 1985 (CVRC)

Recommended areas : All Over India

Production conditions : All situations

Average yield : 1.9 t/ha

Characteristics : Most widely adapted variety in the country. It is a bold seeded variety with > 6 g/1000 seeds weight having 40% oil content. It matures in 140 days.

Karan Rai

National Capital Region of Delhi

Pusa Aditya (NPC-9)

Year of release : 2006 (SVRC)

Recommended areas : National Capital Region of Delhi

Production conditions : Timely sown rainfed

Average yield : 1.4 t/ha

Characteristics : It performs well under rainfed situation on marginal and poor lands. It is immune to downy mildew, resistant to white rust and tolerant to *Alternaria* blight, *Sclerotea* stem rot and powdery mildew. It is tolerant to aphid under field conditions. It matures in 166 days and the seeds have 40% oil content.

Pusa Swarnim (IGC-01)

Year of release : 2003 (CVRC)

Recommended areas : Rajasthan, Punjab, Haryana, Delhi, Himachal Pradesh, Jammu & Kashmir and western Uttar Pradesh

Production conditions : Irrigated and rainfed

Average yield : Irrigated: 1.7 t/ha; Rainfed: 1.5 t/ha

Characteristics : It has a very high degree of drought tolerance. It is totally free from white rust and has very low incidence of *Alternaria* blight. Seed is of yellow colour with 40-43% oil content. It matures in 165 days.

Recommended cultivation practices

Seed rate: 3.0-4.0 kg/ha; **Spacing:** Row to row 30-45 cm, plant to plant 10-15 cm; **Depth of sowing:** 2.5-3.0 cm; **Time of sowing:** last week of August to first week of September (Early sowing), 15-20 October (Timely sowing), 1-20 November (Late sowing); **Fertilizers (NPK & S, kg/ha):** 60-80:40:40:40 (Apply half quantity of nitrogen and full quantity of other fertilizers as basal dose and the remaining nitrogen after first irrigation). In case of rainfed farming, all fertilizers are halved and applied as basal dose; **Irrigation:** Depending upon water availability, one irrigation at 60-70 days after sowing, two irrigations at 40-50 and 90-100 days after sowing, respectively, and three irrigations at 35-40 days after sowing, 35-40 days after first irrigation i.e. flower initiation; and 30-35 days after second irrigation, i.e., pod formation; **Weed control:** Spraying of the solution of 2.2 litres Fluchloralin in 600-800 litres of water/ha before sowing and mixing it immediately or spraying of Pendimethalin 30 EC @ 3.3 litres solution in 600-800 litres of water within 1-2 days after sowing; **Disease control:** Seed treatment by Metalaxyl (Apron 35 SD) @ 6 g/kg seed or Carbendenzim (Bavistin) @ 2g/kg seed for white rust. Spray Ridomil M Z - 72 WP @ 2 g/litre of water for control of white rust or 1-2 sprays of Mencozeb (Indofil M-45/Dithane M- 45) @ 2 g/litre of water for control of *Alternaria* blight and white rust in 600-800 liters of water; **Insect control:** Dusting of Malathion (5% dust) @ 20-25 kg/ha on the appearance of painted bug (*bagarada*) and Monocrotophos 35 WSC or Dimethoate 30 EC or Methyl demeton 25 EC or Thiomedan 25 EC @ 1000 ml/ha or Malathion 50 EC @ 1250 ml/ha in 500-800 liters of water for control of aphids.

Soybean

During the year 2010-11, soybean was cultivated in an area of 9.55 million hectares in India with a production of 12.66 million tonnes and a productivity of 1325 kilograms per hectare. The improved varieties of soybean developed by IARI are given below:

National Capital Region

Pusa 9712

Year of release : 2005 (SVRC)

Recommended areas : National Capital Region of Delhi

Production conditions : Timely sown irrigated

Average yield : 2.05 t/ha

Characteristics : It is resistant to yellow mosaic virus, soybean mosaic virus, bacterial pustule, charcoal rot, *Myrothecium* leaf spot and stem fly. It matures early in 116 days.

Northern Plains Zone

Pusa 9814

Year of release : 2006 (CVRC)

Recommended areas : Northern Plains Zone

Production conditions : Timely sown irrigated

Average yield : 2.25 t/ ha

Characteristics : Resistant to yellow mosaic, soybean mosaic virus, pod blight and charcoal rot; moderately resistant to stem fly.

Recommended cultivation practices

Seed rate: 75 kg/ha; **Spacing:** Row to row 45 cm, plant to plant 5 cm; **Depth of sowing:** 3-5 cm; **Time of sowing:** June- July; **Fertilizers (NPK & S, kg/ha):** 25-80-50-20 as basal dose; **Irrigation:** 3-4 irrigations in the absence of rainfall; **Weed control :** Mix upper layer of soil with the solution of Fluchloralin @ 2 litres/ha in 750 litres of water before sowing; **Disease control:** Two sprays of confidor @ 250 g/ha for control of mosaic and Bavistin for leaf spot disease in 500 litres of water at the stages of 25 and 45 days; **Insect control:** Spray of Imidacloprid (17.8%) 20-25 g a.i./ha for control of hairy caterpillar, and Malathion 50 EC (800 ml) in 400-500 litres water/ha for control of white fly and leaf borer.

Fodder Crop

Forage Sorghum

All Over India

Pusa Chari Hybrid 106

Year of release	:	1996 (CVRC)
Recommended areas	:	All India
Production conditions	:	For sowing in summer & *kharif* seasons and irrigated
Average yield	:	68-70 t/ha (green fodder), and 16-17 t/ha (dry fodder)
Characteristics	:	It is the first hybrid variety of forage sorghum from a public organization. Leaves are dark green, which remain green for a long time, stalk juicy and sweet with less toxic elements. The quantity of protein is 0.79 or 0.8 t/ha. This variety is ready within 50-55 days for first cutting.

National Capital Region

Pusa Chari 615

Year of release : 2006 (SVRC)

Recommended areas : National Capital Region of Delhi

Production conditions : Timely sown irrigated

Average yield : 70.0 t/ha (green fodder), 20.0 t/ha (dry fodder) and 1.5 t/ ha (seed yield)

Characteristics : A high yielding multi-cut forage sorghum variety with 10-12 dark green leaves/plant, medium thick stalk and stay green character.

Pusa Chari Hybrid 109

Year of release : 2003 (SVRC)

Recommended areas : National Capital Region of Delhi

Production conditions : Timely sown irrigated

Average yield : 70-75 t/ha (green fodder) and 15-17 t/ha (dry fodder)

Characteristics : Multi-cut hybrid. It becomes ready for cutting in 55-60 days and has low HCN content (54.3 ppm). It possesses field tolerance to major insect-pests and foliar diseases.

Recommended cultivation practices

Seed rate: 12-15 kg/ha(small seeded), 20-25 kg/ha(bold seeded); **Spacing:** Row to row 30 cm; **Depth of sowing:** 3-5 cm; **Time of sowing :** March to August (irrigated) or after onset of monsoon ; **Fertilizers (NPK, kg/ha):** 60-40-30 as basal dose and 20 kg N after every cutting; **Irrigation:** 4-5 irrigations in the absence of rainfall; **Weed control :** Spraying the solution of Fluchloralin @ 2.0 litres/ha in 750 litres of water before sowing; **Disease control:** Sprays @ 0.2% of Dithane M-45 and Zineb at 15 days interval for control of leaf spot and wilt; **Insect control:** Sprays of Quinalphos (5% G) 750 g a.i./ha in 600-800 litres of water for stem borer and sowing of Furadon treated seeds (16-20g Carbofuron 25 ST/100 kg seed) for saving the crop from attack of shoot fly.

Fibre Crop

Cotton

During the year 2010-11, cotton in India was cultivated in an area of 11.14 million hectares and its total production was 33.00 million bales (1 bale=170 kgs) with a productivity of 510 kilograms lint per hectare.

Aurobindo (PSS 2)

Year of notification : 2007 (SVRC)

Recommended areas : West Bengal

Production conditions : *Rabi* season

Average yield : 0.8-1.0 t/ ha

Characteristics : It is an extra early maturing variety of *Gossypium hirsutum,* maturing in about 135-140 days, more or less determinate in growth habit, tolerant to jassid and high temperature. It is suitable for growing in warm and humid conditions of *rabi* and *kharif* seasons of West Bengal.

Recommended cultivation practices

Seed rate: 15-20 kg/ha; **Spacing:** 60 cm row-to-tow, 30 cm plant-to-plant; **Depth of sowing:** 4-5 cm; **Time of sowing :** 15-25 May; **Fertilizers (NPK, kg/ha):** 80:30:30, half dose of N and full doses of P and K as basal and the remaining half dose of N at flowering stage; **Weed control**: Spray Pendimethalin @ 1.5 kg active ingredient/ha in 1000 liters of water as pre-emergence weedicide; **Irrigation**: 3-4 (last irrigation at one-third boll opening); **Seed treatment**: Carbendazim @ 2g/kg seed for seed borne diseases and 10 ml Chloropyriphos in 100 ml water for 1 kg seed for control of termites, in case it is a problem; **Insect control**: Spray Dimethoate 30 EC or Methyl Demeton 25 EC 500 ml/ha (for aphids, jassid and thrips), Cypermethrin @ 500 ml/ha (for spotted boll worm), Trizophos @ 1500 ml/ha (for white fly and pink boll worm), Prophenophos @ 1250 ml/ha (for pink boll worm).

Tobacco

Lichhavi

Year of release : 2001(IVRC, ICAR, Research Complex for Eastern Region, Patna)

Recommended areas : All tobacco growing areas of Bihar

Production conditions : Recommended planting geometry is 90 cm x 90 cm

Average yield : 2.7-2.8 t/ha. First grade cured leaf yield is 1.7 t/ha

Characteristics : The leaves are long, wide, thick and green in colour. High yield potential, suitable for *khainee,* cured leaves are dark green in colour with profuse spangling and puckering. Taste is better than that of P.T. 76 and Vaishali Special. It matures in 140-145 days.

Vaishali Special

Year of release : 1993 (CVRC)

Recommended areas : All tobacco growing areas of Bihar

Production conditions : Recommended planting geometry is 90 cm x 75 cm.

Average yield : 2.5 t/ha and the first grade cured leaf yield is 1.65 t/ha.

Characteristics : The leaves are long, wide, creased at midrif, highly puckered and spangled. Cured leaves have good quality white encrustation, sharp in taste and have sweet flavour. Tolerate to black petiole, suitable for *khainee*. It matures in 140-145 days.

P.T. 76

Year of release : 1990 (CVRC)

Recommended areas : All tobacco growing regions of eastern India.

Production conditions : This variety is more suitable for heavy soils where local Bori and Kaunia types are being grown.

Average yield : 2.65 t/ha and the first grade cured leaf yield is 1.7 t/ha.

Characteristics : The leaves are large, wide creased at midrib, light green in colour, profusely spangled and puckered. Cured leaves are soft in texture, dark brown with white encrustation and sharp in taste with appealing flavour, suitable for *khainee*. It matures in 140-145 days.

Prabha

Year of release : 1981 (SVRC, Bihar)

Recommended areas : All tobacco growing areas of Bihar.

Production conditions : It is an early maturing variety, 15 days earlier than other varieties. Therefore, this variety is suitable under multiple cropping system. Recommended planting geometry is 90 cm x 60 cm.

Average yield : 2.2 t/ha

Characteristics : The leaves are large, profusely spangled and puckered. Cured leaves are attractive dark brown in colour with white encrustation and sharp in taste. It matures in 120-125 days.

Sona

Year of release	:	1977 (SVRC, Bihar)
Recommended areas	:	All tobacco growing areas of Bihar particularly those with heavy soil.
Production conditions	:	It should be planted at a distance of 90 cm x 75 cm.
Average yield	:	2.3 t/ha and cured first grade leaf yield is 1.5 t/ha.
Characteristics	:	Its leaves are half open, bereft of leaf stalk, thick, completely filled with spangling and puckering. The cured leaves are sharp in taste with appealing flavour, suitable for *khainee*. Cured leaves are dark brown. The leaves are ready for harvesting in 130-135 days.

Gandak Bahar

Year of release	:	1976 (SVRC, Bihar)
Recommended areas	:	All regions of Bihar under tobacco cultivation.
Production conditions	:	It is suitable for heavy soil. Should be planted with a planting geometry of 90 cm x 90 cm.
Average yield	:	1.85 t/ha and the yield of cured first grade leaves is 1.2 t/ha.
Characteristics	:	Its leaves are large, long, wide, open and dark green, suitable for *khainee*. Cured leaves are brown with white encrustation, spangling is medium. It matures in 135-140 days.

DP 401

Year of release	:	1961 (SVRC, Bihar)
Recommended areas	:	Tobacco cultivated areas of Bihar
Production conditions	:	It is suitable for heavy soils. Should be planted at a distance of 90 cm x 60 cm.
Average yield	:	1.5-2.0 t/ha
Characteristics	:	The leaves are long and leaf margin is bent downwards on all sides. Cured leaves are dark brown in colour, full of white encrustation and sharp in taste. It matures in 130-135 days.

2

Improved Varieties of Vegetables

In India, total vegetables production has crossed 137.68 million tonnes from an area of over 8.21 million hectares with a productivity of 16.8 metric tonnes/hectare. However, the productivity of vegetables is very low. For enhancing the productivity, the Institute has developed many varieties, the details of which are given below:

Solanaceous Vegetables

Tomato

A. Improved Varieties

Pusa Rohini

Year of release : 2005 (SVRC, Delhi)
Area of adaptation : Delhi and NCR
Average yield : 41.2 t/ha
Characteristics : Plants determinate, fruits red, round, smooth, medium sized (70 g), thick pericarp (0.6 cm), longer shelf-life, better market appeal and suitable for long distance transportation and processing. Maturity in 120 days.

Pusa Sadabahar

Year of release : 2004 (SVRC, Delhi)
Area of adaptation : Delhi and NCR
Average yield : 25-35 t/ha
Characteristics : Plants determinate, prolific bearer; fruits red, oval to round, small, smooth and attractive, suitable for growing under a wide range of temperature (8 - 30 °C).

Pusa Uphar

Year of release : 1996 (CVRC)
Area of adaptation : Delhi and Haryana
Average yield : 37 t /ha
Characteristics : Plants indeterminate, prolific bearer, upright, compact with dark-green foliage; fruits in bunches with 4-6 fruits per bunch, attractive, round, medium sized, thick-skinned and uniform ripening.

B. Hybrids

Pusa Hybrid 8

Year of release : 2001 (CVRC)
Area of adaptation : Punjab, U.P., Bihar and Jharkhand
Average yield : 43-45 t/ha
Characteristics : Plants determinate; fruits medium (75-80g), round, uniform ripening and good for long distance transportation.

Pusa Hybrid 4

Year of release : 1997 (CVRC)
Area of adaptation : M.P. and Maharashtra
Average yield : 55 t/ha
Characteristics : Plants determinate; fruits medium, round, yellow stem end, uniform ripening, good for long distance transportation. Field resistance to root knot nematode.

Pusa Divya (Hybrid)

Year of release : 1997
Area of adaptation : Suitable for zone-IV and central hilly region
Average yield : 35-45 t/ha
Characteristics : Plants long, height 105-170 cm with more branching. Fruits 3-5 per bunch. Ripened fruits thick-skinned, round to oval shape and dark red in colour. First picking 70-90 days after transplanting.

Pusa Hybrid 2

Year of release : 1996 (CVRC)

Area of adaptation : J&K, H.P., Uttarakhand, Punjab, U.P., Bihar, Rajasthan, Gujarat, Haryana, Delhi, M.P. and Maharashtra

Average yield : 55 t/ha

Characteristics : Plants determinate; fruits red, round, medium, firm, suitable for long distance transportation, available from March-end to May-end, field resistant to nematode.

Recommended cultivation practices

Seed rate: 400-500 g/ha (common variety), 150-200 g/ha (hybrid); **Spacing**: 60 cm x 45 cm; **Time of sowing:** July- August *(kharif)*, Oct-Nov *(rabi)*, Feb (spring- summer), Transplanting 30-35 DAS; **Fertilizer (NPK, kg/ha):** 100:50:50, full doses of P& K as basal, half dose of N after 15 days and another half dose of N after 35 days of transplanting; **Irrigation**: First irrigation after transplanting and thereafter at 10 days interval; **Weed control**: Spraying of Stomp @ 2.5 litres/ha just after transplantation; **Disease control** : For damping off, seed treatment by Thiram @ 2 g/kg seed; **Insect control** : For control of fruit borer, spraying of 0.1% Carbaryl and for white flies and jassids, spraying of Metasystox @ 0.05%.

Brinjal

A. Improved Varieties

Pusa Shyamla

Year of release : 2004 (CVRC)

Area of adaptation : Punjab, Uttar Pradesh, Bihar and Jharkhand

Average yield : 39 t/ha

Characteristics : Plants non-spiny with erect branches; light purple pigmentation partially on younger leaves. Fruits long, glossy, attractive, dark purple, each fruit weighing 80-90 g. First picking 50-55 days after transplanting.

Pusa Ankur

Year of release : 1998 (CVRC)
Area of adaptation : Rajasthan, Gujarat, Haryana, Delhi, M.P. and Maharashtra
Average yield : 35 t/ha
Characteristics : Fruits small (60-70 g), slightly oval, dark purple, glossy; first picking 45 -50 days after transplanting.

Pusa Uttam

Year of release : 1997 (CVRC)
Area of adaptation : Punjab, U.P., Bihar and Delhi
Average yield : 40 t/ha
Characteristics : Plants non-spiny; fruits slightly oval, glossy, dark purple, medium sized (200-250 g); first picking 60 days after transplanting.

Pusa Purple Cluster

Year of release : 1997
Area of adaptation : Suitable for plains of northern India and hilly regions
Average yield : 20 t/ha
Characteristics : Fruits 10-12 cm long, dark purple, 4-9 fruits per bunch. Suitable for bacterial wilt infested areas.

B. Hybrids

Pusa Hybrid 9

Year of release : 1997 (CVRC)

Area of adaptation : Gujarat and Maharashtra

Average yield : 50 t/ha

Characteristics : Plants non-spiny with upright branches; leaves green with light pigmentation on younger leaves; fruits slightly oval, dark-purple, glossy with partially pigmented stalk and calyx, weight 250 g; first picking 55-60 days after transplanting.

Pusa Hybrid 5

Year of release : 1994 (CVRC)

Area of adaptation : Gangetic and central plains, Kerala, Tamil Nadu, Karnataka and Andhra Pradesh

Average yield : 52 t/ha

Characteristics : Plants upright, spineless; fruits long, medium sized, dark purple; first picking 50-55 days after transplanting.

Pusa Hybrid 6

Year of release : 1993 (CVRC)

Area of adaptation : Delhi, Haryana, U.P. and Punjab

Average yield : 45 t/ha

Characteristics : Plants upright, non-spiny; fruits round, purple, glossy, medium sized (200 g); suitable for autumn-winter; first picking 55-60 days after transplanting.

Recommended cultivation practices

Seed rate: 400-500 g/ha (Hybrid 150-200 g/ha); **Spacing:** 60-75 cm x 60 cm; **Time of sowing:** May-June *(kharif)*, February- March *(spring-summer)*, transplanting 35-40 DAS; **Fertilizer (NPK, kg/ha):** 100:50:50, full doses of P & K as basal, half dose of N after 15 days and another half dose of N after 35 days of transplanting; **Irrigation:** First irrigation after transplanting and subsequent irrigation as and when required; **Weed control**: Spraying of Stomp @ 2.5 litres/ha just after transplantation; **Insect control:** For shoot & fruit borers, spray of Deltamethrin (2.8 EC)1 ml/litre of water.

Sweet Pepper

California Wonder

Year of Release : Exotic introduction recommended by the station

Area of adaptation : Medium to higher hilly regions

Average yield : 180-200 q/ha

Characteristics : Plant height medium, fruits shining green, 3-4 lobes. First picking 75 days after planting.

Pusa Deepti (Hybrid)

Year of Release : 1997

Area of adaptation : Temperate and subtropical regions of Northern India

Average yield : 300-350 q/ha

Characteristics : Plant medium, busy and erect, fruits yellowish green, conical; turns dark red at maturity; First picking 70-75 days after planting.

Yolo Wonder

Year of Release : Exotic introduction recommended by the station

Area of adaptation : Medium to higher hilly regions

Average yield : 150-180 q/ha

Characteristics : Plant height medium with broad foliage; fruits dark green, 3-4 lobes; First picking 90-100 days after planting.

Chilli

Improved Variety

Pusa Jwala

Year of release : 1983 (CVRC)

Area of adaptation : Through out India

Average yield : 8.5 t/ha (green) and 1.8 t/ha (dry).

Characteristics : Plants dwarf, bushy, light green; fruits 9-10 cm long, light green, ripe fruits light red, highly pungent; fairly tolerant to thrips and mites.

Paprika

Kt-pl-19

Year of Release : 1994

Area of adaptation : South Indian regions

Average yield : 300-350 kg/ha (for seed); 360-500 q/ha (for fresh fruits); 57-75 q/ha (for dry fruits)

Characteristics : Plant erect with more number of branches pendent fruit bearing, non-pungent; blossom end sharp curved, dark green colour fruits turns dark red on maturity.

Recommended cultivation practices

Seed rate: 1.0-1.5 kg/ha; **Spacing:** 45-60 cm x 30-45 cm; **Time of sowing:** Feb-Mar, June-July, transplanting 30-40 DAS; **Fertilizer (NPK, kg/ha):** 120:50:50, P & K full, half N as basal dose and remaining N before flowering; **Irrigation:** First irrigation after transplanting and subsequent irrigations after 10-12 days interval during winter and once in a week during summer; **Weed control**: Two to three hoeing and weeding are necessary to keep the field free from weeds; **Disease control:** For damping off, treat the seeds with Thiram 2 g/kg seed and for anthracnose, spray Dithane M-45 or Bavistin @ 2 g/litre of water; **Insect control:** Spray Metasystox @ 0.05% for control of white flies, aphids and jassids.

Bottle gourd

A. Improved Varieties

Pusa Santushti

Year of release : 2005 (SVRC, Delhi) and 2007 (CVRC)

Area of adaptation : Delhi and Haryana

Average yield : 28-29 t/ha *(kharif)*, 26.1 t/ha (summer)

Characteristics : Fruits attractive green, smooth, pear shaped, fruit length 18.50 cm, fruit diameter 12.40 cm, sets fruit under low temperature (10-12 °C) as well as high temperature (35-40 °C), fruit weight 0.8 -1.0 kg. Maturity in 55-60 days.

Pusa Sandesh

Year of release : 1994 (SVRC, Delhi)

Area of adaptation : Suitable for commercial cultivation in spring-summer and *kharif* seasons in northern plains

Average yield : 32 t/ha

Characteristics : Fruits attractive green, round, deep oblate, medium sized, weighing 600 g; first picking in 55-60 days in *kharif* and 60-65 days in spring /summer.

Pusa Naveen

Year of release : 1992 (CVRC)

Area of adaptation : M.P. and Maharashtra

Average yield : 32.5 t/ha

Characteristics : Fruits 15-18 cm in girth, green; prolific bearer; suitable for both summer and *kharif* seasons; first picking in 60-65 days.

B. Hybrid

Pusa Hybrid 3

Year of release : 1993 (SVRC, Delhi)

Area of adaptation : Delhi, Haryana, U.P. and Punjab.

Average yield : 42.5 t/ha (summer), 47 t/ha *(kharif)*

Characteristics : Fruits green, suitable for easy packing and long distance transportation; first picking in 50-55 days.

Recommended cultivation practices

Seed rate : 6-8 kg/ha (variety), 5-7 kg/ha (hybrid); **Spacing:** 120 cm x 60 cm; **Time of sowing:** February-March, July -August; **Fertilizer (NPK, kg/ha):** 100:50:60 kg/ha, all N, P & K as basal dose and 1% urea solution spray at flowering stage; **Irrigation :** Need based irrigation initially and every fifth day during flowering stage; **Weed control**: Two hoeing and weeding are necessary to keep the field free from weeds; **Disease control:** Spray 0.1% Kerathane for powdery mildew and 0.2% Dithane M-45 for downy mildew; **Insect control:** Spray 0.2% Carbaryl for red pumpkin beetle and Thiodon @ 3 ml/litre of water for control of fruit fly.

Cucumber

Improved Variety

Pusa Uday

Year of release : 2004 (SVRC, Delhi)
Area of adaptation : Delhi and NCR
Average yield : 15.6 t/ha
Characteristics : Fruits medium in size (13-15 cm long), light green in colour with whitish green stripes (originating from blossom-end and running upto one-third of the fruit length), straight, non-prickled and soft skinned. Maturity in 48-52 days.

Recommended cultivation practices

Seed rate: 2-2.5 kg/ha; **Spacing:** 150 cm x 60 cm; **Time of sowing:** February-March, June-July; **Fertilizer (NPK, kg/ha):** 100:50:60, all N, P & K as basal dose and spray 1% urea solution at flowering stage; **Irrigation**: Need based initially and every fifth day during flowering stage; **Weed control**: Two hoeing and weeding are necessary to keep the field free from weeds; **Disease control:** Sprays 0.1% Karathane for powdery mildew and 0.2% Dithane M-45 for downy mildew; **Insect control**: Spray 0.2% Carbaryl for red pumpkin beetle and Thiodon @ 3 ml/litre of water for control of fruit fly.

Sponge gourd

Improved Variety

Pusa Sneha

Year of release : 2004 (SVRC, Delhi)
Area of adaptation : Delhi and NCR
Average yield : 12 t/ha
Characteristics : Fruits medium long (20-25 cm), smooth, almost straight and dark green with blackish green narrow stripes having tender flesh and hard skin, suitable for long distance transportation. Maturity in 45-50 days, tolerant to high temperature, suitable for spring-summer and rainy seasons in northern plains.

Recommended cultivation practices

Seed rate: 4-5 kg/ha; **Spacing:** 200 cm x 75 cm; **Time of sowing:** February-March, June-July; **Fertilizer (NPK, kg/ha):** 100:50:50, all N, P&K as basal dose; **Irrigation:** Irrigation at 5-6 days interval; **Weed control:** Two hoeings and weedings are necessary; **Disease control:** Sprays 0.2% Dithane M-45 for downy mildew; **Insect control :** Spray Malathion 50 EC @ 0.1% solution for the control of fruit fly.

Bitter gourd

A. Improved Variety

Pusa Vishesh

Year of release : 1986 (SVRC, Delhi)

Area of adaptation : Delhi and Haryana

Average yield : 15 t/ha

Characteristics : Fruits thick, medium long, glossy green; suitable for spring-summer season; vines short, hence more number of plants can be accommodated per unit area; first picking in 55-60 days.

B. Hybrids

Pusa Hybrid 1

Year of release : 1990 (SVRC, Delhi)

Area of adaptation : Spring-summer and rainy seasons in northern plains

Average yield : 20 t/ha

Characteristics : Fruits medium long, medium thick, glossy-green; suitable for pickling and dehydration; yield higher than Pusa Vishesh and Pusa Do Mausami; first picking in 55-60 days; Suitable for growing in spring- summer season.

Pusa Hybrid 2

Year of release : 2002 (CVRC)

Area of adaptation : Punjab, Uttar Pradesh, Bihar, Jharkhand, Chhattisgarh, Orissa, A.P., Rajasthan, Gujarat, Haryana and Delhi

Average yield : 18 t/ha

Characteristics : Fruits dark green, medium long and medium thick (fruit length 12.5 cm and breadth 4.5 cm) with irregular smooth ridges. The average fruit weight is 85-90 g. Maturity in 52 days.

Recommended cultivation practices

Seed rate: 5-6 kg/ha; **Spacing:** 120 cm x 60 cm; **Time of sowing:** February-March, June-July; **Fertilizer (NPK, kg/ha):** 100:50:50, all N, P&K as basal dose; **Irrigation:** Irrigation at 5-6 days interval during summer season; **Weed control**: Two hoeing and weeding are necessary to keep the field free from weeds; **Disease control:** Spray 0.2% Dithane M- 45 for downy mildew; **Insect control:** Spray Malathion 50 EC @ 0.1% solutions or Deltamethrin 2.5 EC 1 ml/litre water for control of fruit fly.

Pumpkin

A. Improved Varieties

Pusa Vishwas

Year of release : 1990 (CVRC)

Area of adaptation : Punjab, Uttar Pradesh, Bihar, Chhattisgarh, Orissa, A.P., M.P. and Maharashtra

Average yield : 40 t/ha

Characteristics : Vigorous vegetative growth; leaves dark green with white spots including veins; fruits light brown, spherical with thick golden-yellow flesh, weight 5 kg; Maturity in 120 days.

Pusa Vikas

Year of release : 1990 (SVRC)

Area of adaptation : Spring-summer and rainy seasons in Delhi and NCR

Average yield : 30 t/ha

Characteristics : Vines semi-dwarf to dwarf (2.0-2.5m long); leaves soft with light green or yellow spots; fruits small weighing 2 kg, flattish round; flesh yellow, rich in vitamin A.

B. Hybrid

Pusa Hybrid 1

Year of release : 1992 (SVRC)

Area of adaptation : Spring-summer and rainy seasons in northern plains

Average yield : 52 t/ha

Characteristics : Fruits flattish round, medium size, weighing 4.75 kg; flesh golden yellow.

Recommended cultivation practices

Seed rate: 6-8 kg/ha; **Spacing:** 120 cm x 60 cm; **Time of sowing:** Feb-Mar, June-July; **Fertilizer (NPK, kg/ha):** 100:50:50, all N,P&K as basal dose and 1% urea solution spray at flowering stage; **Irrigation:** Irrigation at 5-6 days interval during summer season; **Weed control**: Two hoeing and weeding are necessary to keep the field free from weeds; **Disease control:** Spray 0.2% Dithane M- 45 for downy mildew; **Insect control:** Spray 0.2% Carbaryl for control of red pumpkin beetle and Thiodon @ 3 ml/litre of water for control of fruit fly.

Summer Squash

Australian Green

Year of Release : Exotic introduction recommended by the station

Area of adaptation : Medium to higher hilly regions

Average yield : 25-30 t/ha

Characteristics : Fruits are dark green with very light green colour stripes, long (25-30 cm); sown during March-April in hills and January- February in plains.

Pusa Alankar (Hybrid)

Year of Release : 1972

Area of adaptation : Medium to higher hilly regions

Average yield : 43-45 t/ha

Characteristics : Fruits are green with shining light green stripes, long (25-30 cm); sown during March-April in hills and January- February in plains.

Cauliflower

A. Improved Varieties

Pusa Paushja

Year of release : 2008 (SVRC, Delhi)

Area of adaptation : Delhi and NCR

Average yield : 30-35 t/ha

Characteristics : Mid-late (December-January) maturity group (temperature 15-20 °C); leaves bluish green, narrow conical leaf top; curd retentive white, very compact weighing about 900 g. Maturity in 85 days after transplanting. Availability period lasts for 20-25 days.

Pusa Meghna

Year of release : 2004 (SVRC, Delhi)

Area of adaptation : Delhi and Haryana

Average yield : 12.5 t/ha

Characteristics : Extra early variety for September maturity group (temperature 22-27 °C). Semi-spreading plants with 30-40 cm height and medium-size; light green petiolated leaves having entire margin; curd white, compact and small to medium-size (350-400 g). Maturity in 95 days.

Pusa Snowball K-1

Year of release : 1988 (CVRC)

Area of adaptation : Uttar Pradesh

Average yield : 30 t/ha

Characteristics : Late (January- March) maturity group; leaves bluish green, narrow conical leaf top; curds snow white, self blanched, very compact. Maturity in 90-95 days after transplanting. Field resistance to black rot.

Pusa Sharad

Year of release : 2004 (CVRC)
Area of adaptation : Punjab, U.P., Bihar, Haryana, Rajasthan, Delhi and West Bengal
Average yield : 24 t/ha
Characteristics : Mid-early (November) maturity group (temperature 15-20 ^{o}C); leaves bluish green with long petiole, narrow apex and ear like lobes at the base of lamina. Curds semi-dome shaped retentive white, very compact, weighing about 900 g. Maturity in 85 days after transplanting.

Pusa Snowball K.T. 25

Year of release : 2004
Area of adaptation : Suitable for hilly and northern plain
Average yield : 17.5-30 t/ha
Characteristics : Late maturity, planting can be done in October-November in northern India. Leaves light green, curd white and compact. Variety resistance to black rot and diamond back moth.

B. Hybrids

Pusa Kartik Sankar

Year of release : 2002 (CVRC)
Area of adaptation : Punjab, U.P., Bihar, Jharkhand, West Bengal and Assam
Average yield : 14.9 t/ha
Characteristics : Early variety for September maturity group (temperature 22-25 ^{o}C). Curds compact, retentive white, medium sized, weighing about 475 g; resistant to downy mildew. Maturity in 96 days.

Pusa Hybrid 2

Year of release : 1994 (CVRC)
Area of adaptation : Punjab, U.P., Bihar, Jharkhand, West Bengal and Assam
Average yield : 23 t/ha
Characteristics : Mid-early (November-December) maturity group (temperature 15-20 ^{O}C); plants medium, semi-erect; curds white, compact, medium size; suitable for sowing in July-end; field resistance to downy mildew. Maturity in 80 days after transplanting.

Sprouting Broccoli

Pusa K.T.S.1

Year of Release : 1996
Area of adaptation : Plains and hilly areas of Northern India
Average yield : 16 t/ha
Characteristics : Plant medium height, dark green, sprouts dark green with small buds weighing 300-400 gm; maturity 90-100 days after planting.

Recommended cultivation practices

Seed rate: 400-500 g/ha; **Spacing:** Early 45 cm x 30 cm, Mid 45cm x 45 cm, Late 60 cm x 45 cm; **Time of sowing:** Mid May-June (early) July end-August start (mid early), end August-September start (mid late), September-October (late); **Fertilizer (NPK, kg/ha):** 120:60:60, full doses of P and K as basal, half dose of N at 15 days after transplanting and the remaining N after 45-55 days; **Irrigation:** First irrigation after transplanting and thereafter 7-10 days intervals; **Weed control**: Two hoeing and weedings, earthing up after 4 weeks; **Disease control:** For damping off, treat the seeds by Thiram 2 g/kg seed and for anthracnose; spray Dithane M-45 or Bavistin @ 2 g/litre of water; **Insect control:** Spray Chlorantraniliprole (2 ml/10 litres of water) for control of semi looper, caterpillar, diamond back moth and Thiamethoxam (2 g /10 litres of water) or Deltamethrin 2.5 EC (1 ml/ litre of water) 10-15 days interval for control of sucking pests.

Cabbage

Improved Variety

Pusa Mukta

Year of release : 1988 (CVRC)
Area of adaptation : Well adapted throughout India
Average yield : 30 t/ha
Characteristics : Plants with short stalk; heads flattish round, medium size; leaves light green with slightly wavy margins; resistant to black rot. Maturity in 70-75 days after transplanting.

Golden Acre

Year of Release : Exotic introduction recommended by the station

Area of adaptation : Throughout India

Average yield : 20-24 t/ha

Characteristics : Suitable for growing in all the regions, early in maturity, small plant, outer non-wrap 4-5 round leaves, green, small, compact heads are ready 60-75 days after planting.

Pusa Drum Head

Year of Release : 1968

Area of adaptation : Temperate and Sub-tropical regions

Average yield : 30 t /ha

Characteristics : Its heads are drum shaped, large flat and compact. Resistant to black leg disease. Maturity 80-90 days after planting.

KGMR-1 (Hybrid)

Year of Release : 2005

Area of adaptation : Jammu and Kashmir, Himachal Pradesh and Uttar Pradesh

Average yield : 35-40 t/ha

Characteristics : Heads are compact, round, green covered with serrated, wavy leaves, it is hybrid resistant to black rot disease and tolerant to high temperature. Its heads have better staying capacity in the field (non-splitting habit)

Recommended cultivation practices

Seed rate: 400-500 g/ha; **Spacing:** 45-50 cm x 30-40 cm; **Time of sowing:** September-November (plains); **Fertilizer (NPK, kg/ha):** 120:60:60, full P&K as basal dose, half dose of N at 15 days after transplanting and the remaining half of N after 45-55 days; **Irrigation:** First irrigation after transplanting and thereafter at 7-10 days intervals; **Weed control :** Two hoeing and weedings, earthing up after 4 weeks; **Disease control:** For damping off, treat the seeds by Thiram @ 2 g/kg seed and spray Dithane M-45 or Bavistin @ 2 g/litre of water for anthracnose; **Insect control:** Spray Chlorantraniliprole (2 ml/10 litres of water) for control of semi looper, caterpillar, diamond back moth and Thiamethoxam (2 g /10 litres of water) or Deltamethrin 2.5 EC (1 ml/ litre of water) 10-15 days interval for control of sucking pests.

Knol-Khol

White Vienna

Year of Release : Exotic introduction recommended by the station

Area of adaptation : Suitable for temperate and sub-tropical regions of north India

Average yield : 20-24 t/ha

Characteristics : Knobs are light in colour; roundish, medium sized. Flesh is white with pleasant fragrance. Maturity 50-60 days after planting.

Pusa Virat

Year of Release : 2008

Area of adaptation : Himachal Pradesh

Average yield : 19.2 t/ha

Characteristics : Knobs are large (800-900 gm, 13-14 cm diameter), round, knobs are non-pithy and without fibre even after maturity.

Brussels Sprout

Hilds Ideal

Year of Release : Exotic introduction recommended by the station

Area of adaptation : Suitable for temperate and sub-tropical regions of north India

Average yield : 16 t/ha

Characteristics : Plants 55-60 cm long, bears 45-50 sprouts. Sprouts are compact with good flavor. Maturity 115 days after planting.

Bulb Crop

Onion

Improved Varieties

Pusa Madhvi

Year of release : 1989 (CVRC)

Area of adaptation : Madhya Pradesh and Maharashtra

Average yield : 35 t/ha

Characteristics : Bulbs medium to large, roundish flat, light red, T.S.S. 11-13% with good keeping quality; maturity in 130-135 days after transplanting.

Pusa Red

Year of release : 1978 (CVRC)

Area of adaptation : Punjab, U.P., Bihar, Rajasthan, Gujarat, Haryana, Delhi, Karnataka, Tamil Nadu and Kerala

Average yield : 30 t/ha

Characteristics : Bulbs medium in size (70-80 g), flattish round, red, less pungent, T.S.S. 12-13%, good keeping quality; matures in 135-140 days after transplanting.

Pusa White Flat

Year of release : 1977 (CVRC)

Area of adaptation : Northern plains

Average yield : 32.5 t/ha

Characteristics : Bulbs medium in size, flattish round with attractive white colour, T.S.S. 12-14%; very good keeping quality; maturity in 125-130 days after transplanting.

Brown Spanish

Year of Release : Exotic introduction recommended by the station

Area of adaptation : 1000 m or higher regions above sea level.

Average yield : 28.5 t/ha (for bulbs)

Characteristics : Bulbs are round, reddish brown. Maturiy 160-180 days after planting.

Recommended cultivation practices

Seed rate: 10-12 kg/ha (*rabi),* 12-15 kg/ha (*kharif*); **Spacing:** 15 cm x 10 cm; **Time of sowing:** Oct.-Nov. (*rabi*), May-June (*kharif*); **Fertilizer (NPK, kg/ha):** 150:60:60, full doses of P & K, half dose of N as basal, one fourth N at 30 days after transplanting and the remaining N after 45-50 days; **Irrigation:** First irrigation after transplanting and thereafter at 10-12 days interval during winter and once a week during summer; **Weed control**: Stomp @ 3.35 litres/ha just after transplanting; **Disease control:** For Stem *phyllium* blight and purple blotch diseases, spray Dithane M -45 @ 0.25% after mixing Sendovit @ 1ml/litre of water; **Insect control:** Spray Malathion 50% EC @ 1 ml/litre of water for control of thrips.

Carrot

Improved Varieties

Pusa Rudhira

Year of release : 2008 (SVRC, Delhi)

Area of adaptation : Delhi and NCR

Average yield : 30 t/ha

Characteristics : Long red roots with self coloured core, triangular shape, suitable for sowing from mid-September to October. The roots are ready for harvest from middle of December onwards.

Pusa Asita

Year of release : 2008 (SVRC, Delhi)

Area of adaptation : Delhi and NCR

Average yield : 25 t/ha

Characteristics : Long black roots with self coloured core, suitable for sowing from September to October. The roots are ready for harvest during December - January. Maturity in 90-110 days.

Pusa Nayanjyoti (Hybrid)

Year of Release : 2009

Area of adaptation : Suitable for cultivation under low temperature throughout India

Average yield : 35-40 t/ha

Characteristics : First hybrid developed by Public Sector with orange colour roots. Roots are orange, smooth, uniform, cylindrical, stumpy with small indistinct self-coloured core. Roots possess high B-carotene content (7.552 mg/100g fresh weight). Sown in April-August in hills and in November-December in the Northern Indian Plains.

Pusa Meghali

Year of release : 1994 (CVRC)

Area of adaptation : Madhya Pradesh and Maharashtra

Average yield : 25 t/ha

Characteristics : Early; roots orange with self-coloured core; short tops. Only variety having orange coloured flesh in the tropical group. Produces seeds in the plains. Suitable for early sowing. Maturity in 100-120 days.

Nantes

Year of release : 1985 (CVRC)

Area of adaptation : Throughout India

Average yield : 12 t/ha

Characteristics : Temperate type; small tops with green leaves; roots well shaped, small, orange, perfectly cylindrical, abruptly ending in small thin tail, sweet and self coloured core with orange flesh.

Pusa Yamdagni

Year of Release : 1985

Area of adaptation : Low temperature conditions throughout India

Average yield : 20-25 t/ha

Characteristics : Roots long slightly tapering, cylindrical with small tops and orange colour roots. Sown in April-August in hills and in October-December in plains. Maturity 90-100 days after sowing.

Recommended cultivation practices

Seed rate: 5-6 kg/ha; **Spacing**: 30 cm x 5-10 cm; **Time of sowing**: September-October; **Fertilizer (NPK, kg/ha)**: 60:40:40, full doses of P&K, half dose of N as basal, one fourth N @ 25-30 days after sowing and the remaining N after 45-50 days after sowing; **Irrigation**: First irrigation after germination and thereafter at 8-10 days interval. **Disease control:** For Cercospora leaf blight seed treatments with Thiram 2.5 g /kg of seed and for the control of Scletotinia rot, spray Carbendazim (50 WP) 1 kg/1000 litres of water; **Insect control:** Spray Imidacloprid 17.8 SL @ 1 ml/3 litres of water for control of carrot weevil.

Radish

Improved Varieties

Pusa Mridula

Year of release : 2005 (SVRC, Delhi)

Area of adaptation : Throughout India

Average yield : 13.5 t/ha

Characteristics : Roots globular in shape, bright red in colour, size (2.9 x 4.1 cm), white flesh with soft texture and mild pungent taste. Leaves dark green and tender. Maturity in 20-25 days after sowing. Suitable for winter crop (September-February).

Pusa Chetki

Year of release : 1988 (CVRC)

Area of adaptation : Throughout India

Average yield : 25 t/ha

Characteristics : Roots pure white, smooth, soft in texture, less pungent in summer sowings, 15-22 cm long, thick and stumpy; leaves entire, slightly lobed, dark green and upright. Maturity in 40-50 days, suitable for summer and rainy season (April-August).

Japanese White

Year of Release : Exotic introduction recommended by the station

Area of adaptation : Higher and lower hilly regions

Average yield : 25-30 t/ha

Characteristics : Roots pure white, long and cylindrical; Maturity 60 days after sowing.

Pusa Himani

Year of Release : 1970

Area of adaptation : High and lower hilly region

Average yield : 32.5 t/ha

Characteristics : Roots are 30-35 cm long, thick, sharp non-stumpy end, white with green top. Its flesh is pure white, crispy with slightly pungent taste and sweet flavor. Maturity 55-60 days after sowing. Suitable for growing from December to February in plains and foot hills and for summer in medium to high altude area.

Recommended cultivation practices

Seed rate: 8-10 kg/ha (Pusa Mridula), 9-12 kg/ha (Pusa Chetki); **Spacing**: 30 cm x 10 cm; **Time of sowing**: September-February (Pusa Mridula), mid-April-August (Pusa Chetki); **Fertilizer (NPK, kg/ha)**: 50:40:40, half of N and full of P&K as basal dose for both Pusa Mridula and Pusa Chetki; remaining half dose of N 15-20 days after transplanting for Pusa Mridula and 30-35 days after transplanting for Pusa Chetki; **Irrigation**: At 6-7 days interval; **Insect control:** Spray Malathion 50% @ 1.0 ml/litre of water for control of aphids.

Turnip

Purple Top White Globe

Year of Release : Exotic introduction recommended by the station

Area of adaptation : Suitable for temperate and sub-tropicals of north India

Average yield : 25-30 t/ha

Characteristics : Roots round shaped, top of root is purple and lower regions is white colour, Maturity 55-60 days.

Pusa Chandrima

Year of Release : 1979

Area of adaptation : Suitable for temperate, sub-tropical and tropical regions of northern India

Average yield : 30-40 t/ha

Characteristics : Roots large round to flattish, white in colour with medium leaf tops. Its outer skin is less deep and flesh white in colour.

Pusa Swarnima

Year of Release : 1979

Area of adaptation : Suitable for temperate, sub-tropical and tropical regions of north India.

Average yield : 35.5 t/ha

Characteristics : Early maturing variety, medium leaf topps, roots flattish and round. Its outer skin light yellow in colour. Suitable for planting in June to October in hilly region and October to December in plain. It matures in 60-70 days.

Garden pea

Improved Varieties

Arkel

Year of release : 1978 (CVRC)

Area of adaptation : Throughout India

Average yield : 7.5-8.0 t/ha

Characteristics : Plants dwarf, 40-60 cm tall; pods attractive, dark green, 8 cm long, slightly curved, very sweet and well filled (7-8 seeds/pod) with wrinkle seed; first picking in 55-60 days.

Recommended cultivation practices

Seed rate: 80-100 kg/ha; **Spacing:** 30 cm x 8-10 cm; **Time of sowing:** October-November; **Fertilizer (NPK, kg/ha):** 30:60:60 as basal dose; **Irrigation:** At 10-15 days interval; **Disease control:** Two sprays of Bavistin @ 1 g/litre of water at 10-12 days interval for control of powdery mildew; **Insect control:** Spray Quinalphos (25 EC) 250 g a.i./ha or Deltamethrin (2.5 EC) 1 ml/3 litres of water for control of pod borer.

French Bean

Contender

Year of Release : 1965
Area of adaptation : Suitable for all regions
Average yield : 20 t/ha
Characteristics : Its plants are dwarf and bushy. Its beans are dark greenish in colour, stringless and slightly curve at end.

Pusa Parvati

Year of Release : 1970
Area of adaptation : Suitable for all regions
Average yield : 22 t/ha
Characteristics : Its plants are dwarf and bushy. Its beans are dark greenish in colour, slightly string, semi round and straight.

Pusa Himlata

Year of Release : 1972
Area of adaptation : Medium and higher hilly regions
Average yield : 17-20 t/ha
Characteristics : Its plants are vine type. Its beans are long, fleshy, light green string less and straight. Its seeds can be used as *rajmash*.

Cowpea

Pusa Sukomal

Year of release : 2005 (SVRC, Delhi)

Area of adaptation : Delhi and NCR

Average yield : 6.2-6.6 t/ha

Characteristics : Plants semi dwarf, erect; pods light green, round, meaty, less fibrous, around 30 cm long and 1 cm thick. Maturity in 42-45 days during *kharif* and 55-60 days during summer. Highly resistant to golden yellow mosaic virus and leaf spot disease.

Recommended cultivation practices

Seed rate: 20-25 kg/ha (bush); **Spacing:** 45-60 cm x 15 cm; **Time of sowing:** June-July, February-March; **Fertilizer (NPK, kg/ha):** 30:60:50 as basal dose; **Irrigation:** At 7-10 days interval; **Weed control:** Spray Stomp @ 3 litres/ha as pre-emergence (2 days after sowing); **Disease control:** Spray Malathion 50% EC @ 1.5 ml/litre of water for control of yellow virus disease; **Insect control:** Spray Thiodon @ 2 ml/litre of water for control of leaf miner.

Dolichos Bean

Pusa Sem 2

Year of release : 1995 (SVRC, Delhi)

Area of adaptation : Delhi and NCR

Average yield : 15 t/ha

Characteristics : Pods dark green, very tender, stringless, semi-round, 16 to 17 cm long with 5-6 seeds per pod, 11-12 pods/spike; excellent organoleptic quality. Highly tolerant to viruses, anthracnose, aphids, jassids, pod borer and frost. First picking in 120-125 days.

Pusa Sem 3

Year of release : 1995 (SVRC, Delhi)

Area of adaptation : Delhi and NCR

Average yield : 15 t/ha

Characteristics : Pods dark green, very tender, stringless, semi round, 16 to 17 cm long with 5-6 seeds per pod, 11-12 pods/spike; excellent organoleptic quality. Highly tolerant to viruses, anthracnose, aphids, jassids, pod borer and frost. First picking in 120-125 days.

Recommended cultivation practices

Seed rate: 10-12 kg/ha; **Spacing:** 100 cm x 30 cm; **Time of sowing:** June-July; **Fertilizer (NPK, kg/ha):** 30:50:50 as basal dose; **Irrigation:** Need based; **Disease control:** Spray Malathion 50% EC @ 1.5 ml/litre of water for control of yellow virus disease; **Insect control:** Spray Malathion 50 EC @ 1.5 ml/litre of water for control of leaf miner.

Leafy Vegetables

Vegetable mustard

Pusa Sag 1

Year of release : 2004 (SVRC, Delhi)

Area of adaptation : Delhi and NCR

Average yield : 70 t/ha

Characteristics : Large, broad, attractive green & glabrous leaves having double dentate margin with round, fleshy, long and light green petiole, 2-3 cuttings, higher carotene and ascorbic acid, very late in bolting (end of January). First harvest 35 days after sowing.

Recommended cultivation practices

Seed rate: 3-4 kg/ha; **Spacing:** 25-30 cm x 10 cm; **Time of sowing:** October-November; **Fertilizer (NPK, kg/ha):** 80:50:50 as basal dose; **Irrigation:** Need based; **Insect control:** Spray Malathion 50 EC @ 1.5 ml/litre of water for control of aphids.

Amaranthus

Pusa Kiran

Year of release : 1993 (SVRC, Delhi)

Area of adaptation : Delhi and NCR

Average yield : 35 t/ha

Characteristics : Leaves and stem glossy green; first harvest after 25-30 days.

Pusa Lal Chaulai

Year of release : 1993 (SVRC, Delhi)

Area of adaptation : Delhi and NCR

Average yield : 45 t/ha (summer) and 40 t/ha *kharif)*

Characteristics : Upper surface of leaves deep red or magenta and lower surface purplish-red; stem deep red; first harvesting after 35 days in spring summer and 25 days in *kharif*.

Recommended cultivation practices

Seed rate: 1.5-2.0kg /ha; **Spacing:** 15-20 cm x 8-10cm; **Time of sowing:** March-July; **Fertilizer (NPK, kg/ha):** 60:40:40; **Irrigation:** Need based; **Insect control:** Spray Malathion 50 EC @ 1.5 ml/litre of water for control of aphids.

All Green

Year of release : 1980

Area of adaptation : Suitable for hilly and plain regions

Average yield : 25-30 t/ha

Characteristics : Plants straight, leaves long, green, thick and soft. Late flowering, suitable for cultivation throughout the year.

Malvaceous Vegetable

Okra

Pusa A-4

Year of release : 1995 (SVRC, Delhi)

Area of adaptation : Delhi and NCR, and throughout India

Average yield : 14 t/ha

Characteristics : Resistant to yellow vain mosaic virus, tolerant to aphids and jassids; fruits dark green, 12-15 cm long; first picking after 45 days.

Recommended cultivation practices

Seed rate: 18-20 kg/ha for spring-summer and 8-10 kg/ha for *kharif*; **Time of sowing:** February-March for spring season, June-July for *kharif* season; **Spacing:** 45 cm x 30 cm for spring summer and 60 cm x 30 cm for kharif crop; **Fertilizer: (NPK, kg/ha):** 100:50:50 all as basal does along with 15t/ha FYM; **Irrigation:** Need based; **Disease control:** Spray of Malathion 50% EC @ 1.5 ml/litre of water for control of yellow virus disease; **Insect control:** Carbofuran @ 1 kg a.i./ha at the time of sowing in rows and spray of Monocrotophos @ 1.5 ml/litre followed by Imidacloprid @ 5ml/10 litre of water after 8-10 days for control of jassid and white fly.

Exotic Vegetables

Lettuce

Chinese Yellow

Year of Release : Introduction recommended by the station

Area of adaptation : Plain and hilly regions

Average yield : 20-24 t/ha

Characteristics : It is an open leaf variety, leaves are light green, crisp and tender.

Great Lakes

Year of Release : Introduction recommended by the station

Area of adaptation : Plain, medium and higher hilly regions

Average yield : 20-25 t/ha

Characteristics : Its wrapping leaves form heads, heads are large cabbage shaped. Leaves dark green, outer unwrapped leaves are blister shaped (puckering).

Celery

Ford Hook Emperor

Year of Release : Introduction recommended by the station

Area of adaptation : Plain and hilly regions

Average yield : 30-35 t/ha

Characteristics : Its a late maturity type, plants dwarf and stout, its pedicels are solid, light green, thick, broad and tender. Leaves and stalks are used in soup, salad and seasoning the vegetables.

Vegetable based profitable crop rotations

According to various geographical areas and climate of the country, some selected crop rotations along with possible income have been presented.

Area	Crop rotation	Yield (t/ha)	Expected cost (₹/ha)	Expected income (₹/ha)	Expected profit (₹/ha)	Selling rate (₹/kg)
Northern Plains Zone	• Early Cauliflower (July-October)	105	50,000	1,57,500	1,07,500	15
	Peas (October-January)	80	20,000	87,500	67,500	08
	Tomato (January-June)	400	62,500	2,00,000	1,37,500	05
	• Okra (June-September)	125	37,500	1,00,000	62,500	08
	Carrot (October-December)	250	30,000	1,25,000	95,000	05
	Cauliflower (December-March)	250	37,500	75,000	37,500	03
	Radish (April-May)	175	15,000	52,500	37,500	03
	• Cucumber (July-September)	125	30,000	1,25,000	95,000	10
	Potato (October-December)	180	37,500	1,08,000	70,500	06
	Onion (January-June)	240	62,500	1,92,000	1,29,500	08
Eastern Zone	• Cauliflower (June-August)	105	40,000	1,57,000	1,17,500	15
	Peas (September-November)	100	25,000	1,00,000	75,000	10
	Radish (December-January)	175	20,000	52,500	32,500	03
	Capsicum (January-May)	150	62,500	1,80,000	1,17,500	12
	• Chillies (June-September)	115	50,000	92,000	42,000	08
	Broccoli (October-December)	110	30,000	1,32,000	1,02,000	12
	Radish (January-February)	150	15,000	45,000	30,000	03
	Potato (February-May)	250	50,000	2,00,000	1,50,000	08
North-Western Hills Zone	• French bean (July-August)	105	37,500	1,05,000	67,500	10
	Knol khol (September-October)	155	25,000	77,500	52,500	05
	Peas (November-April)	100	25,000	1,00,000	75,000	10
	Capsicum (April-June)	150	62,500	2,25,000	1,62,500	15
	• Tomato (June-September)	400	62,500	2,00,000	1,37,500	05
	Cabbage (September-November)	225	37,500	1,12,500	75,000	05
	Coriander (December-February)	62	17,500	93,000	75,500	15
	Potato (March-May)	250	50,000	1,50,000	1,00,000	10

Area	Crop rotation	Yield (t/ha)	Expected cost (₹/ha)	Expected income (₹/ha)	Expected profit (₹/ha)	Selling rate (₹/kg)
Eastern Plains Zone	• Parwal (February-June)	12.5	37,500	1,00,000	62,500	08
	Brinjal (July-October)	30.0	45,000	1,50,000	1,05,000	05
	Cauliflower (November-Jan.)	25.0	37,500	1,00,000	62,500	04
	• Cowpea (July-October)	12.5	25,000	1,00,000	75,000	08
	Tomato (November-January)	27.5	62,500	2,20,000	1,57,500	08
	Bitter gourd (February-April)	20.0	30,000	1,60,000	1,30,000	08
	Amaranthus (May-June)	7.5	17,500	37,500	20,000	05
South Zone	• Tomato (June-October)	31.2	50,000	3,12,500	2,37,500	10
	French bean (November-Jan.)	12.5	25,000	1,25,000	1,00,000	10
	Okra (February-May)	15.0	30,000	1,50,000	1,20,000	10
	• Cowpea (June-August)	16.2	25,000	1,30,000	1,05,000	08
	Tomato (September-Dec.)	30.0	50,000	3,00,000	2,50,000	10
	Water melon (Dec./Jan-May)	25.0	37,500	2,50,000	2,12,500	10

Additional crop production in intercropping vegetables

S. No.	Principal crops	Intercrops
1.	Cabbage	Lettuce / Radish / Fababean
2.	Tomato	Radish / Carrot / Knol khol / Spinach
3.	Cucumber	Cabbage / Cauliflower / Radish
4.	Bottle gourd	Okra / Chilli
5.	Brinjal	Spinach / Radish / Red Amaranthus
6.	Okra	French bean / Radish
7.	Potato	Radish / Coriander
8.	Elephant footyam	Cucurbits / Cowpea
9.	Cassava	Onion / Cowpea
10.	Capsicum	French bean / Radish / Spinach / Fenugreek

By growing radish, carrot, knol khol, etc. on beds, additional income can be obtained.

Cultivation of radish almost round the year

Radish is one of the important salad vegetable crops required thoughout the year. Being a long day crop a particular variety of it cannot be employed for growing roots throughout the year. IARI has developed different cultivars having specific growing requirements. The following five cultivars can be sown under north Indian plains from August and continued to December so as to make fresh radishes available to the consumers throughout the year.

Cultivars	Period of sowing	Period of harvesting
Pusa Desi	Mid-August to Mid-October	Mid-September to Mid-December
Pusa Mridula	1st fortnight of Sept. to Mid-November	2nd fortnight of October to 1st fortnight of January
Japanese White	Mid-October to 2nd fortnight of December	Mid-December to 1st fortnight of March
Pusa Himani	2nd fortnight of Dec. to end of February	Mid-February to 3rd week of April
Pusa Chetki	1st week of April to mid-August	1st fortnight of May to 2nd fortnight of September

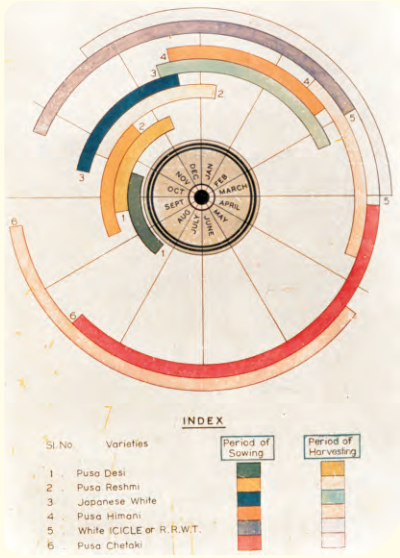


Chart showing year round radish production

Cultivation of cauliflower in different seasons

The Institute has played a pivotal role in developing specific varieties for different temperature regimes. Based on temperature requirement for growth and curd development, cauliflower varieties have been classified into four groups, viz., early, mid-early, mid-late and late types. With these varieties, it has become possible to grow cauliflower for almost throughout the year.

Maturity group	Varieties and hybrids	Sowing time	Mean temp. required for curd initiation & development	Availability period
Early I(a)	Pusa Meghna Pusa Kartik Sankar	End of May	22-27 °C	End of August -October
Early I(b)	Pusa Deepali	June	20-25 °C	Oct.-Nov.
Mid Early II	Pusa Sharad Pusa Hybrid 2	End of July-August	16-20 °C	Nov.-Dec.
Mid Late III	Pusa Paushja Pusa Shukti	End of Aug.-Sept.	12-16 °C	Dec.-Jan.
Late	Pusa Snowball K-1 Pusa Snowball K-25	Sept.-Nov.	10-16 °C	Jan.-March

Note: *Suitable for cultivation under North Indian plains*

Pusa Meghna

Improved technique for raising vegetable nursery

A vegetable nursery is a place where young vegetable seedlings are raised or handled until they are ready for permanent planting in the field. This is a technical job that requires careful attention at different stages of growth. Vegetables are raised first in the nursery and, when the seedlings attain proper size, they are transplanted in the well-prepared field.

Details of important vegetables raised in the nursery

S. No.	Crop	Improved varieties	Sowing time in nursery	Seed rate for raising nursery for a hectare	Age of seedling for transplanting (weeks)
1	Brinjal	Pusa Shyamla Pusa Purple Cluster Pusa Uttam Pusa Upkar Pusa Bindu Pusa Ankur Pusa Hybrid 5 Pusa Hybrid 6 Pusa Hybrid 9	(i) December-January (ii) May-June	400-500 g	7-8 5-6
2	Tomato	Pusa 120 Pusa Rohini Pusa Uphar Pusa Sadabahar Pusa Sheetal Pusa Gaurav Pusa Hybrid 1 Pusa Hybrid 2 Pusa Hybrid 4 Pusa Hybrid 8	(i) December-January (ii) August-Sept.	400-500 g	7-8 5-6
3	Chilli	Pusa Jwala Pusa Sadabahar	(i) December-January (ii) June-July	800-1000 g	7-8 4-5
4	Sweet pepper	California Wonder Yellow Wonder Pusa Deepti	(i) June-July (ii) December-January	1.0-1.5 kg	4-5 6-7
5	Cauli-flower	(i) Pusa Meghna	(i) May-June	600-750 g	4-5
		(ii) Pusa Deepali	(ii) July-August		4-5
		(iii) Pusa Sharad	(iii) August-September		5-6
		(iv) Pusa Snow Ball K-1 Pusa Snow Ball K-25	(iv) October-November	375-400 g	
6	Cabbage	(i) Golden Acre Pusa Drum Head and Pusa Mukta	(i) September-October	400-500 g	5-6

S. No.	Crop	Improved varieties	Sowing time in nursery	Seed rate for raising nursery for a hectare	Age of seedling for transplanting (weeks)
7	Knol Khol	White Vienna	September-November	1.0-1.5 kg	4-5
8	Broccoli	Pusa Broccoli Kt-1	September-November	375-400 g	4-5
9	Brussels Sprouts	Hilds Ideal	September-October	400-500 g	4-5
10	Chinese Cabbage	Exotic varieties	October-November	400-500 g	4-5
11	Onion	(i) Pusa Red Pusa Ratnar Early Grano and Pusa Madhvi	(i) Main crop : October-November;	8-10 kg	6-7
		(ii) N-53 and Agrifound Dark Red	(ii) Kharif crop : Late May-June	10-12 kg	5
12	Leek	Exotic varieties	(i) March (ii) July	8-10 kg	6-7
13	Lettuce	Great Lakes Chinese Yellow	September-October	500 g	4-5
14	Celery	Ford Hook Emperor Exotic varieties	September-October	150-200 g	8-10
15	Parsley	Moss curled Exotic varieties	September-October	200-250 g	8-10

Tools and equipments for nursery

Spade, *khurpi*, watering can, fork, hoe, garden line, roller, sticks, baskets, *sirkies*, polythene sheets, sprayer, duster, etc., are required for various operations.

Location and layout of nursery

Before laying out the nursery, the following points should be considered:

1. Land for nursery should be well drained and located at a high level.
2. The soil of the land should be sandy loam and normal in pH (6.5-7.0).
3. The nursery area should be selected near to a water source.
4. Nursery plots should be chosen near the farm buildings so that frequent supervision can be made easily.
5 Nursery plots should be away from shady places.
6 Nursery plots should be selected on one side of the field to isolate the other field for doing cultural practices easily.

Low cost polyhouse technology for raising off-season nursery of cucurbitaceous vegetables

Technological details

Low cost poly house

Low cost polyhouse

The low cost polyhouse is a zero-energy chamber made of polythene sheet of 700 gauge supported on bamboos with *sutli* and nails. Its size depends on the purpose and availability of space. It has only one opening which is kept ajar for 1-2 hr during the day. The structure depends on the sun for heating. The temperature inside polyhouse is 6-10 °C higher than that as outside. The cold waves during December-January do not enter the polyhouse and the inside environment becomes conducive for quick germination of seeds and growth of young seedlings.

The polythene bags of 16.5 cm x 10 cm size are used for sowing the seed and raising the cucurbit seedlings in the polyhouse. Before filling these polythene bags with the mixture of garden soil, sand and compost in 1:1:1 ratio, 4-5 small holes are made at the bottom and side of each bag. The bags are filled with the said mixture keeping 2-3 cm vacant from the top. The filled bags are kept inside polyhouse in groups in such a way that one person can easily sow the seeds and work. A polyhouse 10 m x 3.5 m size can easily accommodate 5000 polythene bags (16.5 cm x 10 cm). An expenditure of 55 paise will be required for raising 1-2 seedlings per bag.

One to two seeds are sown in each bag during the last week of December or 1st week of January after treating them with captaf @ 2 g/litre of water. After sowing, a thin layer of sand is put to fill the top of the polybags in order to facilitate proper germination. After sowing the seed, light irrigation is given by watering can. After 25-30 days of sowing, the seedlings become 10-12 cm long and then they are kept outside the polyhouse for 2-3 days for hardening. In the first week of February when danger of frost is over, the seedlings are transplanted on the northern slope of prepared channels in the field after removing the polythene bags with the help of a blade without disturbing the earth ball. After transplanting, light irrigation is given for better establishment of plants.

Details of raising off-season (winter) seedlings of cucurbits

Total area (length - 10.0 m x width - 3.5 m)	=	35 sq.m.
Height towards north	=	2.0 m
Height towards south	=	1.8 m
Opening (width - 0.75 m and height - 2.0 m)		
Path in the middle - 0.75 cm wide and 10 m long		
Vacant space between each of two nursery groups for sitting and working	=	0.4 m wide
Total number of polythene bags in 10 x 3.5 m polyhouse	=	5000

Materials required for making polyhouse and their cost

1. Bamboos : (i) 2.35 m x 7.5 cm size = 20, total cost	=	₹ 350/-
(ii) 3.50 m x 7.5 cm size = 40, total cost	=	₹ 720/-
Life of bamboo is 3-4 years; so cost of bamboo for one year or one season	=	₹ 270/-
2. Polythene sheet (700 gauge, 3.6 m width, 40 m length)	=	₹ 450/-
3. *Sutli*	=	₹ 50/-
4. Thin wire pieces (15 cm long)	=	₹ 50/-
5. Iron nails (1.5 cm long) = 500 g	=	₹ 50/-
6. Labour required for making the polyhouse (@ ₹ 90/- per labour)	=	₹ 630/-
7. Polythene bags 400 gauge (16.5 x 10 cm size) (5000 @ ₹ 250/- per thousand bags)	=	₹ 1,250/-
Total cost for making polyhouse and raising 5000 seedlings	=	₹ 2,750/-
Cost of raising one or two seedling(s) in each bag	=	₹ 0.55

Seed production of vegetables crops - A profitable enterprise

In commercialized agriculture, the farmers can multiply their profit by undertaking seed production of varieties/hybrids of vegetable crops.

Profit by commercialization and seed production of varieties of vegetable crops developed by IARI

Crop	Seed rate (per ha)	Selling rate (₹/kg)	Seed yield (kg/ha)	Expected price (₹ /ha)	Product-ion cost (₹ /ha)	Profit (₹ /ha)
Cauliflower	OP-500 g	OP- 1200	125	1,50,000	62,000	88,000
(early)	F1-400 g	F1-5000	100	5,00,000		4,38,000
Cauliflower	OP-350 g	OP-1200	250	3,00,000	50,000	2,50,000
(mid)	F1-200 g	F1-5000	125	6,25,000		5,75,000
Cauliflower (late)	OP-350 g	OP-1200	375	4,50,000	47,000	4,03,000
Cabbage	OP-300 g	OP-800	375	3,00,000	47,000	2,53,000
	F1-200 g	F1-5000	175	8,75,000		8,28,000
Tomato	OP-400 g	OP-1200	250	3,00,000	62,000	2,38,000
	F1-200 g	F1-20000	100	20,00,000	1,00,000	19,00,000
Brinjal	OP-300 g	OP-800	250	2,00,000	62,000	1,38,000
	F1-200 g	F1-16000	100	16,00,000	47,000	15,00,000
Chilli	OP- 400 g	OP -800	200	1,60,000	62,000	98,000
Bottle gourd	OP-3 kg	OP-450	250	1,12,000	45,000	65,000
	F1-2 k g	F1-1800	100	1,80,000	62,000	1,18,000
Bitter gourd	OP-4 kg	OP-500	125	62,000	42,000	17,000
	F1-3 kg	F1-2000	90	1,80,000	62,000	1,18,000
Ash gourd	OP-3 kg	OP-500	375	1,87,000	42,000	1,58,000
	F1-2 kg	F1-2000	110	2,20,000	62,000	37,000
Sponge gourd	OP-4 kg	OP-450	150	67,000	30,000	37,000
Ridge gourd	OP-4 kg	OP-450	150	67,000	30,000	37,000
Carrot	OP-5 kg	OP-500	250	1,25,000	30,000	80,000
	F1-3 kg	F1-4000	200	8,00,000	45,000	7,55,000
Radish	OP-9 kg	OP-350	750	2,62,000	45,000	2,17,000
Turnip	OP-3 kg	OP-320	1000	3,20,000	45,000	2,75,000
Beet root	OP-20 kg	OP-400	1100	4,40,000	45,000	3,95,000
Frenchbean	OP-70 kg	OP-170	1250	2,12,000	40,000	1,72,000
Cowpea	OP-35 kg	OP-150	1300	1,95,000	40,000	1,55,000
Spinach	OP-25 kg	OP-90	1000	90,000	37,000	53,000
Amaranthus	OP-2 kg	OP-250	1200	3,00,000	37,000	2,63,000
Vegetable mustard	OP-5 kg	OP-150	1000	1,00,000	37,000	63,000

OP - Open Pollinated Variety, F1 - Hybrid

3

Improved Fruit Varieties and Production Technologies

The area under fruit crops during the year 2010-11, was 6.62 million hectares with a production of 75.82 million tonnes. Many improved varieties of important fruit crops have been developed by the Institute. Through the availability of appropriate varieties for better nutritional qualities, high yield and enhancement in keeping quality, and preservation, increase in export can be secured. The details about improved varieties developed by IARI are given below :

Developed Varieties

Mango

Pusa Shreshth

Parentage : Amrapali x Sensation
Year of release : 2011 (Institute Variety Release Committee)
Recommended region : Plains of North, West and South India
Average yield : 20-22 kg per tree
Characteristics : It is a unique hybrid having regularity in bearing, attractive elongated shape, red peel and orange pulp. Plants are semi-vigorous and suitable for closer planting (6 m x 6 m). Fruit medium sized (228 g) with attractive red peel colour and higher pulp content (71.9%). The total soluble solids are 20.3%, vitamin C (40.3 mg/100 g pulp) and -carotene content (10,964 g/100 g pulp). It has pleasant flavour with shelf life (7 to 8 days) at room temperature. It is suitable for domestic market as well as international market.

Pusa Pratibha

Parentage : Amrapali x Sensation
Year of release : 2011 (Institute Variety Release Committee)
Recommended region : Plains of North and Central India with probability in Penninsular India
Average yield : 40-42 kg per tree
Characteristics : Regular bearer, semi-vigorous and suitable for closer planting (6 m x 6 m). Fruits are attractive in shape having bright red peel and orange pulp. The red peel colour on golden yellow background makes it very appealing to buyers. Fruit size is medium (181 g) with higher pulp content (71.1%). Pulp with medium TSS (19.6 ^{o}Brix), vitamin C (34.9 mg/100 g pulp) and -carotene content (11,474 g/100 g pulp). It has pleasant flavour with improved shelf life (7 to 8 days) at room temperature. Potential mango variety for international market.

Pusa Lalima

Parentage : Dashehari x Sensation

Year of release : 2011 (through Institute Variety Release Committee)

Recommended : Plains of North and Central India

Average yield : 50-60 kg per tree

Characteristics : Regular bearer, semi-vigorous and are suitable for closer planting. Fruits are attractive in shape and having red peel and orange pulp. The fruit (209 g) having attractive red peel colour and higher pulp content (70.1%). Pulp with medium total soluble solids (19.7%), vitamin C (34.7 mg/100 g pulp) and high -carotene content (13,028 g/100 g pulp). It has good flavour with shelf life (5 to 6 days) at room temperature. It is suitable for domestic market as well as international market.

Pusa Peetamber

Parentage : Amrapali x Lal Sundari

Year of release : 2011 (through Institute Variety Release Committee)

Recommended : Plains of North, West and South India

Average yield : 20-25 kg per tree

Characteristics : It is regular bearer, semi-vigorous and suitable for closer planting (278 plants/ha). Fruits are having attractive oblong shape, bright yellow peel. It is moderately resistant to mango malformation and major insect pests of mango. The fruits weight about 213 g with attractive yellow peel colour with higher juicy pulp (73.6%). It has medium total soluble solids (18.8%), rich in vitamin C (39.8 mg/100 g pulp) and -carotene content (11,737 g/100 g pulp). It has appealing flavour with shelf life (5 to 6 days) at room temperature. It is suitable for domestic market as well as international market.

Pusa Arunima

Parentage : Amrapali x Sensation

Year of release : 2002 (SVRC, Delhi)

Recommended region for cultivation : All over India

Average yield : 15-20 kg per tree (10th year)

Characteristics : Regular bearer, semi-vigorous and suitable for closer planting (6 m x 6 m). Fruits medium to large in size (230 to 250 g) with attractive red peel and medium TSS (19.5 ^{O}Brix). It is suitable for both domestic and international markets, with long shelf-life (10 to 12 days) at room temperature after ripening.

Pusa Surya

Parentage : Selection from Eldon

Year of release : 2002 (SVRC, Delhi)

Recommended region for cultivation : All over India

Average yield : 12-15 kg per tree (10th year)

Characteristics : Trees semi-dwarf and suitable for closer planting (6 m x 6 m). Fruit ripens by mid-July in northern India, medium to large (260 to 290 g) with attractive apricot-yellow peel colour with pink-blush. Pulp with medium TSS (19.0 ^{O}Brix) with long shelf-life (10 to 12 days) at room temperature after ripening. Suitable for both domestic and international markets.

Mallika

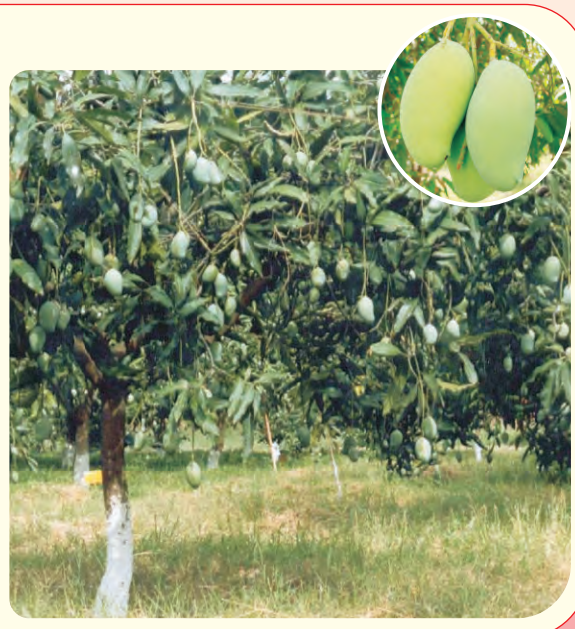
Parentage : Neelum x Dushehari

Year of release : 1971 (Institute Variety Release Committee)

Recommended region for cultivation : All over India especially for eastern, southern and coastal regions

Average yield : 18-20 kg per tree (10th year)

Characteristics : World's first mango hybrid released for commercial cultivation. Regular in bearing with semi-vigorous growth habit. Size of the fruit large (307g), good taste (TSS 24 °Brix), fibreless with good flavour. Fruits ready for harvest by the 3rd week of July in northern India. Suitable for processing and export. It has become a major commercial export variety of Karnataka, Andhra Pradesh and West Bengal.



Amrapali

Parentage : Dushehari x Neelum

Year of release : 1979 (Institute Variety Release Committee)

Recommended region for cultivation : All over India

Average yield : 15-20 kg per tree (10th year)

Characteristics : Distinctly dwarf, highly regular and precocious. Fruits ready for harvest by the 3rd week of July in northern India. Fruit size small to medium (120 to 160 g) and fibreless. It has high TSS (22.8 °Brix) and β-carotene content (16,830 µg/100g pulp). Suitable for blending mango pulp. Ideal for high density planting (1,600 plants per ha).

Recommended cultivation practices

Planting distance: Mallika - 6 m x 6 m, Amrapali - 2.5 m x 2.5 m, Pusa Arunima - 6 m x 6 m, Pusa Surya- 6 m x 6 m; **Planting time**: July-August in northern India; **Fertilizer and manure application**: Ammonium Sulphate, Single Super Phosphate and Potassium Sulphate mixture in the ratio of 1:3:1(0.5 kg) + 10 kg FYM/ tree and increase subsequently, i.e., up to 10th year 3-5 kg+ 60 kg FYM /tree. Thereafter, a equal dose is applied in splits; **Disease control**: Spray 200 ppm Napthalene Acetic Acid (NAA) in the month of October for control of floral malformation followed by deblossoming in January and 250 g Karathane in 500 litres of water/ha for control of powdery mildew disease; **Insect control:** The holes made by stem borer may be filled by 1% Diazinon with petrol after cleaning the holes with thin wire and covering with clay mud.

Grape

Pusa Seedless

Parentage : Clonal selection from Thompson Seedless

Year of release : 1970 (Institute Variety Release Committee)

Recommended region for cultivation : North Indian Plains

Average yield : 8- 10 kg per vine (head system)

Characteristics : Bunch elongated with golden yellow coloured berries. Ripens by the first week of June in northern India. Berries medium (500-750 g), long cylindrical and seedless and have high TSS (22-24 ^{O}Brix) and are highly responsive to GA_3 application. Suitable for both table purpose and raisin making.

Pusa Navrang

Parentage : Madeleine Angevine x Rubi Red

Year of release : 1996 (Institute Variety Release Committee)

Recommended region for cultivation : North Indian Plains and Central India

Average yield : 10-12 kg per vine (head system)

Characteristics : Early ripening (1st week of June in northern India), basal bearer (4-6 nodes), and teinturier variety (containing red pigment both in peel and pulp) with high antioxidant content. Bunch loose, medium in size with round and medium sized berries. Suitable for coloured juice and wine making. Resistant to anthracnose.

Pusa Urvashi

Parentage : Hur x Beauty Seedless

Year of release : 1996 (Institute Variety Release Committee)

Recommended region for cultivation : North Indian Plains and Central India

Average yield : 10-12 kg per vine (head system)

Characteristics : Early ripening (1st week of June in northern India), basal bearer (4-6 nodes). Bunch loose and medium in size with seedless greenish-yellow berries. The pulp TSS varies from 20 to 22 ^{O}Brix. Suitable for table purpose and raisin making. Tolerant to anthracnose and powdery mildew.

Recommended cultivation practices

Planting distance: On Head system 1.5 -2.0 m, Bower system 2.5 -3.5 m. 'Y' and extended Y- system can also be adopted; **Pits and filling method:** Pits (0.5 x 0.5 x 0.5 m) are filled with 10 kg FYM + 30 ml Chlorpyriphos, add 1.0 kg Super Phosphate + 0.5 kg Potassium Sulphate; **Training and pruning**: Starts in second year; **Pruning**: Pusa Seedless (8-10 nodes), Pusa Navrang (4-6 nodes) and Pusa Urvashi (4-6 nodes); **Disease control:** Two sprays of 0.1% Karathane at an interval of 10-15 days for control of powdery mildew disease; **Insect control:** Dusting of Lindane powder in rainy season for control of chaffer beetle.

Lemon

Kagzi Kalan

Parentage : It is a lemon selection

Year of release : 1990 (recommended by Division of Fruit and Horticulture)

Recommended region for cultivation : All over India

Average yield : 7-10 kg per tree (after 10 years)

Characteristics : Recommended for summer months in northern India. The plant semi-vigorous, low spreading and prolific bearer, starts bearing after three years of planting. The first crop is ready for harvest from the month of May till August and the second crop is harvested in December-January. Fruits medium to large in size (40-50 g) and extremely juicy, it has good processing traits.

Recommended cultivation practices

Planting distance: 5 x 5 m; **Planting time:** July-August in northern India; **Fertilizer and manure application:** 20 kg FYM +1.0 kg Single Super Phosphate, 2 kg Ammonium Sulphate and 1 kg Potassium Sulphate in 5th year; **Disease control:** Spray Bordeaux Mixture 5:5:50 on plants after removing canker infected branches; **Insect control:** Spray Dimethoate 30% EC @ 2 ml /litre of water for control of leaf miner and aphids.

Papaya

Pusa Giant

Parentage : Selection from Ranchi variety

Year of release : 1981 (from IARI Regional Station, Pusa, Bihar)

Recommended region for cultivation : All over India in tropical and sub-tropical regions

Average yield : 30-35 kg per plant

Characteristics : Dioecious variety with male and female plants. The plants most vigorous and produce large size fruits. Fruiting starts at a height of 92 cm, total height of the plant is 220 cm. The shape of the fruit is oblong with 18 cm x 10 cm seed cavity and 5 cm thick flesh. Colour is yellow to orange and TSS ranges from 7 to 8.5^{O}Brix. The average weight of the fruit ranges from 1.5 to 3 kg and the yield per plant is 30-35 kg. An outstanding feature of this variety is the tolerance of its plants to strong winds. It is highly suitable for preparation of *petha* and for culinary purpose.

Pusa Majesty

Parentage : Selection from Ranchi variety

Year of release : 1986 (from IARI Regional Station, Pusa Bihar)

Recommended region for cultivation : All over India in tropical and sub-tropical regions

Average yield : 35-40 kg per plant

Characteristics : A gynodioecious variety with good keeping quality, suitable for papain fruiting starts at a height of 48 cm, total height of the plant is 196 cm. Fruit size medium to big, seed cavity 17 cm x 9 cm, firm flesh of 3.5 cm thickness with a TSS 9 ^{O}Brix. The average weight of the fruit ranges from 1 to 2.5 kg and the yield per plant is 35-40 kg. It is tolerant to nematode, and virus.

Pusa Delicious

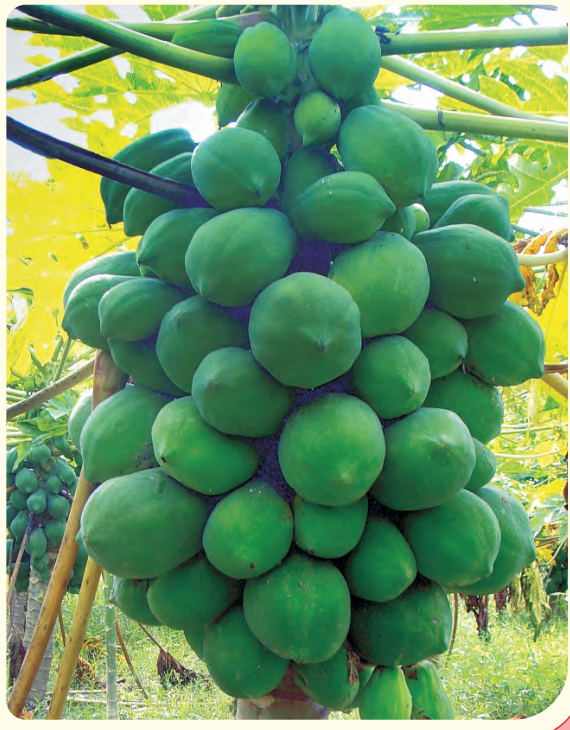
Parentage : Selection from Ranchi variety

Year of release : 1986 (from IARI Regional Station, Pusa Bihar)

Recommended region for cultivation : All over India

Average yield : 40-45 kg per plant

Characteristics : A gynodioecious variety with female and hermaphrodite plants, fruiting starts at a height of about 80 cm from ground level. The maximum height attained is 216 cm. Fruit in size is medium to large in shape in size. It is round oblong in shape with 14 cm x 8 cm seed cavity and 5 cm thick flesh. The fruit weight ranges from 1 to 2 kg and the yield per plant is about 40-45 kg. The fruits are excellent in taste with deep orange coloured flesh, good flavour, and TSS 10-13 ^{O}Brix.



Pusa Nanha

Parentage : Evolved through mutation breeding from Ranchi variety

Year of release : 1983 (from IARI Regional Station, Pusa Bihar)

Recommended region for cultivation : All over India in tropical and sub-tropical regions

Average yield : 25-30 kg per plant

Characteristics : An ultra dwarf dioecious variety of papaya developed through mutation breeding. Fruiting starts at a height of 30 cm and the total height of the plant is 120 cm. The fruit is small to medium with yellow coloured, 3.0 cm thick flesh. The yield per plant is 25 to 30 kg. It is highly suitable for high density planting and kitchen gardening and planting during September-October month is better.

Pusa Dwarf

Parentage : Selection from Ranchi variety

Year of release : 1986 (from IARI Regional Station, Pusa Bihar)

Recommended region for cultivation : All over India in tropical and sub-tropical regions

Average yield : 40-45 kg per plant

Characteristics : A dioecious variety with dwarf and precocious plant. Fruiting starts at a height of 40 cm and the total height of the plant is up to 130 cm. The fruit is small to medium with 12 cm x 8 cm seed cavity and 3.5 cm thick flesh. The flesh colour is yellow to orange and TSS ranges from 6.5 to 8 ^{O}Brix. Each fruit weights about 1.0 to 1.5 kg. The yield per plant is 30-40 kg. This variety is suitable for high density planting and planting during September-October month is better.

High density papaya orchard

High Density Planting Technique

The Institute, keeping in view the shrinking holding sizes and other management problems, has developed a new system of High Density Plantation (HDP) technique for various fruit crops. The advantages of HDP are as follows:

Maximum utilization of land and other resources

More income in less time due to higher productivity

Income during initial periods

Better control of weeds and proper utilization of water and nutrients

Mango

1. Amrapali has been recommended for closer planting (2.5 m x 2.5 m) in a triangular system.
2. One thousand and six hundred (1,600) plants/ha can be accommodated compared to only 80-100 plants/ha for any commercial cultivar planted at 10 to 12 m in a square system.
3. A grower can harvest yield as high as 22 tonnes/ha in the 10th year of fruiting.
4. Annual mild pruning (30 to 45 cm) is recommended at the end of July or the first week of August to sustain production and improve fruit quality after 10 to 12 years of fruiting.
5. Under HDP one can earn ₹ 1,00,000 to ₹ 1,30,000 per annum.

Comparative cost and profit under Conventional method and High Density Planting technique

Particulars	Conventional method	High density plantation
Distance (m)	10 x 10	2.5 x 2.5
Plants/ha	100	1,600
Expenditure for establishment (₹)	35,000	75,000
Annual expenditure (₹)	25,000	40,000
Period of regular yield (years)	8 - 10	7 - 8
Yield (kg/ha)	6,000 - 8,000	16,000 - 19,000
Selling value of fruits* (₹)	54,000 – 72,000	1,44,000 - 1,71,000
Net profit (₹)	29,000 – 47,000	1,00,000 - 1,30,000

* Rate of fruits @ ₹ 9/kg

Citrus (Kinnow Mandarin)

1. A novel concept of high density orcharding in Kinnow mandarin was developed by raising the plants on Troyer citrange rootstock spaced 6' x 6' apart in a square system (3,086 plants/ha).
2. A grower can harvest yield as high as 22-25 tonnes/ha in the 7th year of fruiting in HDP.
3. By adopting HDP, one can earn up to ₹ 1,48,000 to ₹ 1,75,000 per annum.

Comparative cost and profit under Conventional method and High Density Planting technique

Particulars	Conventional method	High Density Plantation
Distance (m)	6 x 6	1.8 x 1.8
Plants/ha	278	3,086
Expenditure for establishment (₹)	35,000	75,000
Annual expenditure (₹)	25,000	50,000
Period of regular yield (years)	5	4
Yield (kg/ha)	10,000 - 12,000	22,000 - 25,000
Selling value of fruits* (₹)	90,000 – 1,08,000	1,98,000 – 2,25,000
Net profit (₹)	65,000 – 80,000	1,48,000 – 1,75,000

* Whole sale rate of fruits @ ₹ 9/kg

Guava

1. By using dwarfing rootstock Pusa Srijan for Allahabad Safeda and also for other commercial cultivars, HDP is possible.
2. Establishing HDP in square system (3m x 3m), 1,111 plants/ha can be accommodated.
3. By using the rootstock Pusa Srijan, three times higher yield (16-18 tonnes/ha) as compared to that of the conventional transplanting method can be realized.

Comparative cost and profit under Conventional method and High Density Planting technique

Particulars	Conventional method	High density plantation
Distance (m)	6 x 6	3 x 3
Plants/ha	278	1,111
Expenditure for establishment (₹)	35,000	50,000
Annual expenditure (₹)	20,000	40,000
Period of regular yield (years)	4	4
Yield (kg/ha)	8,000 -10,000	16,000 - 18,000
Selling value of fruits* (₹)	56,000 –70,000	1,12,000 - 1,26,000
Net profit (₹)	36,000 – 50,000	72,000 – 86,000

* Whole sale rate of fruits @ ₹ 7/kg

Papaya

1. Establishing HDP was possible with the use of Pusa Dwarf variety.
2. Pusa Dwarf and Pusa Nanha varieties could be planted very close (1.25 m × 1.25 m) in square system and consequently 6,400 plants/ha may be accommodated.
3. The system is ideal under drip irrigation system. By adopting this system, one can earn ₹ 2,75,000-3,25,000 per hectare.

Comparative cost and profit under Conventional method and High Density Planting technique

Particulars	Conventional method	High Density Plantation
Distance (m)	2.4 x 2.4	1.25 x 1.25
Plants/ha	1,736	6,400
Expenditure for establishment (₹)	40,000	75,000
Annual expenditure (₹)	25,000	50,000
Period of regular yield (years)	2	2
Yield (kg/ha)	45,000- 50,000	80,000-90,000
Selling value of fruits* (₹)	2,25,000 – 2,50,000	4,00,000 – 4,50,000
Net profit (₹)	1,60,000 – 1,85,000	2,75,000 – 3,25,000

* Whole sale rate of fruits @ ₹ 5/kg

Improved Propagation Techniques for Fruit Plants

Mango

Veneer grafting

1. Veneer grafting is highly economical, easy and gives a very high degree of success (96%) for establishing *in situ* orchards.
2. It has become the most commercialized method of propagation in mango.

Epicotyl/Stone Grafting

Epicotyl/Stone Grafting method is a standardized and highly successful method of mango propagation in Konkan and other coastal regions, where high humidity prevails.

Guava

Stooling

1. Stooling technique has been standardized for faster multiplication of guava varieties.
2. It can be successfully practiced twice a year, and because of which, one can get 30-40 stools/plant/year.
3. The technique has become commercial in India and has replaced inarching and air-layering.

Rootstock Development

Mango

Kurukkan

Kurukkan is a salt tolerant rootstock identified for mango cultivation in saline areas. Plant growth, extent of bearing and fruit quality of Amrapali grafted on Kurukkan have been found to be on par with those of the plant grafted on seedling rootstocks.

Citrus

Troyer Citrange

Troyer citrange induces dwarfing in Kinnow and has been recommended for high density planting. With the use of different rootstocks, namely, Troyer citrange, Karna khatta and Soh Sarkar in Kinnow, the availability of fruits can be extended for a longer period, i.e., from the end of November to mid January.

Sweet orange

Cleopatra mandarin

Cleopatra mandarin has been recommended as a potential rootstock for *mosambi* and pineapple varieties. It improves fruit quality.

Guava

Pusa Srijan

Parentage : Aneuploid - 82 hybrid evolved as Seedless x Allahabad Safeda

Year of release : 2004 (Delhi State Variety Release Committee)

Salient features : Extremely dwarf rootstock, hence, recommended for high density planting.

Fruit Nursery - An Alternative Enterprise

With the expansion in area under horticultural crops and increasing demand for the planting material of improved varieties, the nursery business has turned into a profitable venture. Nursery business is a high profit entrepreneurial option near cities or on the lands located on highways, where the invested capital may yield maximum profit. Nursery business provides an attractive option of self-employment to unemployed and educated youth, which can be accomplished through various Central Government schemes as well as loans and financial aids from nationalized banks. Anyone could earn ₹ 50,000 to 3,00,000 per annum from a small to medium sized nursery. The IARI extends periodical help to the youth through advisory services, training programmes, etc., to establish the nursery business.

Intercropping in Fruit Orchards

Intercropping in fruit orchards is an effective economic option. The fruit trees are usually planted at a distance of 6 to 12 m, which start fruiting at the age of 4-5 years. By intercropping with short duration vegetable crops such as cauliflower, cabbage, tomato, brinjal, chillies, okra, spinach, fenugreeks, field crops like mustard, sesamum, gram, urd, moong, etc., and fruit crops like papaya and phalsa, the fruit growers can earn an additional ₹ 15,000 to 30,000/ha/year from the orchard area.

4

Improved Varieties of Flowers

Floriculture as a commercial activity is still largely practiced on small farms all over India. Flower crops are cultivated in an estimated area of 1,91,000 hectares and this large area generates a total production of 1.03 million tonnes of loose flowers and 69,027 million cutflowers (2010-11). The improved varieties of flowers developed by IARI can meet the increasing market demand for flowers with higher quality and yield. The selection of improved varieties for enhancing income is very necessary. The information of improved varieties of various flowers crops developed by the Institute is as below:

Rose

Pusa Arun

Parentage : Queen Elizabeth x Jantar Mantar

Year of release : 2005 (Institute Variety Release Committee)

Recommended area : Northern plains

Average yield : Each plant produces 20 flowers in winter and 35-40 flowers in spring

Characteristics : Dazzling dark red, large sized, double blooms on strong and long shoots. The petals (numbering 38-40) are thick, fleshy and dark red in colour. This variety is tolerant to red scale and powdery mildew. The blooms are mildly fragrant and are suitable for cut flower industry and exhibition purposes.

Pusa Shatabdi

Parentage : Jadis x Century Two

Year of release : 2005 (Institute Variety Release Committee)

Recommended area : Northern plains

Average yield : Each plant produces 20-30 flowers in winter and 35-40 flowers in spring

Characteristics : Produces very attractive light pink coloured flowers. The petals (numbering 35-40) are fleshy and pink in colour. The variety is moderately tolerant to powdery mildew and leaf spot diseases. The blooms, mildly fragrant, are suitable for cut flower industry and exhibition purposes.

Pusa Ajay

Parentage : Pink Parfait x Queen Elizabeth
Year of release : 2005 (Institute Variety Release Committee)
Recommended area : Northern plains
Average yield : Each plant produces 15-20 flowers in winter and 35-40 flowers in spring
Characteristics : Foliage pigmented, glossy and dark pink coloured flowers. The petals (numbering 35-40) are fleshy and dark pink in colour. Recurrent blooming. It is moderately tolerant to powdery mildew and black spot diseases. The blooms, mildly fragrant, are suitable for cut flower industry and exhibition purposes.

Pusa Komal

Parentage : Pink Parfait x Suchitra
Year of release : 2005 (Institute Variety Release Committee)
Recommended area : Northern plains
Average yield : Each plant produces 40-45 flowers in winter and 60-65 flowers in spring
Characteristics : Completely thornless, the variety produces as many as 60 flowers, very attractive pink coloured flowers, which are mostly borne in clusters. The petals (numbering 50-60) are delicate and are light pink in colour. It is moderately tolerant to insect pests like thrips and diseases like powdery mildew and black spot. The blooms are mildly fragrant and are suitable for growing in pots and beds.

Pusa Mohit

Parentage : Suchitra x Christian Dior
Year of release : 2002 (SVRC, Delhi)
Recommended area : Northern plains
Average yield : Each plant produces 20 flowers in winter and 45 flowers in spring
Characteristics : Thornless, red petals with lighter shade on the reverse side of petals, tolerant to black spot.

Recommended cultivation practices

Spacing: 50-60 cm.; **Budding:** February–March; **Planting:** September-October; **Pruning:** First fortnight of October; **Fertilizer requirement:** 75 g N, 125 g P_2O_5 and 100 g K_2O/1.44 m^2 area and 4-5 kg FYM; **Irrigation:** As per need; **Disease control:** Spray Captan @ 0.2% for black spot; **Insect control:** Parathion for red scale and Malathion @ 0.1% for control of aphids .

Marigold

African Marigold

Pusa Basanti Gainda

Parentage : Golden Yellow x Sun Giant

Year of release : 1995 (Institute Variety Release Committee)

Recommended area : Throughout India

Average yield : Fresh flowers 20-25 t/ha; seed 70-100 kg/ha

Characteristics : Produces medium sized, lemon yellow flowers in 135-145 days after sowing. Ideal for garden display and pot culture.

Pusa Narangi Gainda

Parentage : Cracker Jack x Golden Jubilee

Year of release : 1995 (Institute Variety Release Committee)

Recommended area : Throughout India. More popular in southern India owing to big flower size

Average yield : 25-30 t/ha of fresh flowers, 100-125 kg/ha of seeds

Characteristics : Produces deep orange flowers with ruffled florets in 125-135 days after sowing. Rich in carotenoids (329 mg/1000 g petals), widely used in poultry industry, food, pharmaceutical and nutraceutical industries.

French Marigold

Pusa Arpita

Parentage	:	Selection from heterozygous (local) population
Year of release	:	2009 (Institute Variety Release Committee)
Recommended area	:	Northern plains
Average yield	:	18-20 t/ha
Characteristics	:	Produces medium sized, light orange flowers during mid December to mid February in northern plains of India.

Recommended cultivation practices

Seed rate: 600-800g/ha; **Spacing:** 45x60 cm; **sowing time:** Last week of July to first week of August; **Fertilizer requirement (NPK, kg/ha):** 120-80-80; **Irrigation:** As per need; **Disease control:** Spray soluble sulphur solution @ 0.2% for powdery mildew and rust diseases; **Insect control:** Spray Dicofol @ 0.3% for red spider.

Gladiolus

Pusa Shubham

Parentage	:	Lucky Shamrock x Green Lilac Open
Year of release	:	2009 (Institute Variety Release Committee)
Recommended area	:	Northern plains
Average yield	:	Produces 1.6-2.3 shoots and more than 2 corms and 20 cormels from each mother corm
Characteristics	:	Cream to yellow coloured florets (14-16) on long sturdy spikes. Early variety, flowers in 72 days. Compact spikes with vase life of 10 days.

Pusa Kiran

Parentage : Selection from open pollinated population from cv. Ave

Year of release : 2009 (Institute Variety Release Committee)

Recommended area : Northern plains

Average yield : Produces 1.9-2.7 shoots and more than 2 corms and 20 cormels from each mother corm

Characteristics : White coloured florets (16-19) on long sturdy spikes, early variety, flowers in 75 days, prolific multiplier and has vase life of 10 days.

Recommended cultivation practices

Quantity of bulbs: 1.5 lakh/ha; **Spacing:** 60 cm; **Sowing:** October to November; **Fertilizer requirement** (NPK, g/m^2): 25-16-25; **Irrigation:** As per need; **Disease control:** Spray of Captan @ 0.2% for black spot; **Insect control:** Mixing of Thimet10 G granules @ 20-25 kg/ha in soil at land preparation for control of chaff cutter and spray of 0.2% Metacid-50 for control of aphids and thrips; **Digging of bulbs:** 45 days after flowering.

Chrysanthemum

Pusa Anmol

Parentage : Gamma ray induced mutant of cv. Ajay

Year of release : 2009 (Institute Variety Release Committee)

Recommended area : Hills and plains to get off season blooms

Average yield : 100-150 flowers /plant

Characteristics : Highly floriferous bushy variety with yellowish pink flowers. Thermo-and photo-insensitive variety that produces three flower flushes in a year (October-November, February-March and June-July) as against one in a majority of the cultivars. Flowers in 85-100 days after transplanting. Ideal for loose flowers and whole plant cut flowers. Blooms remain fresh for 20-22 days in field condition as well as in vase.

Pusa Centenary

Parentage : Gamma ray induced mutant of cv. Thai Chen Queen

Year of release : 2009 (Institute Variety Release Committee)

Recommended area : Hills and plains to get off season blooms

Average yield : 10-12 standard flowers /plant

Characteristics : A vigorous growing variety that produces very big yellow flowers. Blooms in 100-110 days after transplanting. Ideal for cut flower. Blooms remain fresh for 20-22 days in field condition as well as in vase.

Recommended cultivation practices

Spacing: 30 x 30 cm; **Time of cutting:** May-June; **Pinching:** After one month; **Transplanting time:** First fortnight of August month; **Time of pinching:** One month after transplanting; **Fertilizer requirement (NPK, kg/ha):** 200-100-100; **Irrigation:** As per need; **Insect control:** To control aphids, spray Rogar (30%) @ 2 ml/litre of water.

5

Agricultural Technologies for Higher Income and Employment

Protected Cultivation

Off-season cultivation of cucurbitaceous vegetables like bottle gourd, summer squash, cucumber, french bean, tomato, etc., during peak winter can be undertaken in protected conditions. The main objective of protected cultivation is to fetch high price for off-season produce and to earn higher profit per unit area. Protected cultivation can be undertaken in the following structures:

Off-season vegetable production under walk-in tunnel during winter

Walk-in tunnel is a temporary structure, erected by the use of G.I. pipes and transparent plastic sheets. It is used for off-season cultivation of vegetables like bottle gourd, summer squash, cucumber, etc., during the entire winter season (December –January). The basic objective and utility of walk-in tunnel is to fetch high price for the off-season produce and to earn higher profit per unit area. The structure is very useful and profitable to vegetable growers.

Optimum size & fabrication

Optimum size (100 m^2)	:	25 m x 4 m (100 m^2)
Design	:	rectangular
Height	:	1.8 m (in middle)
Width	:	4.0 m (approximate)
Length	:	25.0 m (optimum)

Required material and cost

Required material	Quantity	Rate (₹)	Expenditure (₹)
G.I. pipe (length 20' x ½" diameter)	10 pipes	400/pipe	4,000/-
Plastic sheet (transparent 15.200 micron thickness)	210 m^2 (7 m x 30 m)	35/m^2	7,350/-
Other fixing material (wire, iron rods, plate, etc.)	-	-	550/-
Labour (one day)	2 labour	-	500/-
	Total		**₹ 12,400/-**

The temporary plastic structure is erected over the crop during the peak winter months of December, January and mid February and thereafter, the structure is removed from the crop. The plastic structure can be used for 8-10 years. This technique is suitable for off-season vegetable cultivation in northern plains and low hills.

Off-season vegetable production technique under walk-in tunnel

S. No.	Crop rotation	Planting time	Crop duration	Yield (t/ha)	Net profit (₹/ha)
1.	Summer squash	November 1-15	Mid Oct. - Mid Feb.	40-50	2,00,000-2,50,000
2.	Bottle gourd	October 15 – November 15	Mid Oct. - Mid Feb.	25-30	2,50,000-3,00,000
3.	Cucumber	October 15 - 31	Mid Oct. - 28th Jan.	15-20	1,00,000-1,50,000
4.	Pumpkin	November 1-15	Mid Oct. - Mid Feb.	30-40	1,50,000-2,00,000
5.	French bean	October 15 – November 15	Mid Oct. - Mid Dec.	6-8	1,00,000-1,25,000
6.	Tomato	mid October-mid February	Mid Oct. - Mid Feb.	20-25	1,00,000-1,50,000

Insect proof net house for healthy and off-season nursery raising

Under open environment in rainy season, it is possible to grow a healthy nursery free from virus infection in a simple insect proof net house by the use of an insect proof nylon net. During the peak summer, when the temperature is 40- 45 ^{O}C, a healthy nursery of early cauliflower, cabbage, etc., can be raised by the use of a 40-50% shade net for covering the insect proof net. Similarly, during the critical winter (December-January), nursery raising of different vegetables under open environment is possible when the insect proof net house is covered with a transparent plastic sheet (thickness 150-200 micron).

Fabrication of insect proof net house

Optimum size : 12.5 m x 4.0 m (50 m^2)

Design : Rectangular

Height : 1.8 m (in middle)

Gates (double) : 1.6 x 1.0 m

Life span of net shade and plastic : 8 to 10 years

Required materials and cost

S.N.	Required material	Quantity	Rate (₹)	Expenditure (₹)
1.	G.I. pipe (length 20' x ½ diameter)	6 pipes	400/pipe	2,400/-
2.	Insect proof net (40 mesh uv stabilized)	100 m^2	40/m^2	4,000/-
3.	Black or green shade net (40% shade net)	80 m^2	30/ m^2	2,400/-
4.	Transparent plastic sheet (thickness 150-200 micron)	80 m^2	35/ m^2	2,800/-
5.	Fixing material (plates, nut bolts, etc.)	as per need	one time	500/-
6.	Labour (skilled labour required)	2 days	-	1,000/-
7.	Miscellaneous expenditure	-	-	2,000/-
		Total		**₹ 15,100/-**

Objectives and utility of insect proof net house

1. A 50 m^2 net house is suitable for raising virus-free nursery of vegetables like tomato, sweet pepper, chilli, etc., for 2-3 acres area in one batch.
2. During summer season, the same shade net is suitable for raising healthy nursery of cauliflower and cabbage after using a black or green coloured shade net over the insect proof net house.
3. During peak winter, a nursery of brinjal, tomato and sweet pepper can be raised for a fixed duration of 30-35 days after covering the insect proof net with a transparent plastic sheet.

Crop rotation for nursery raising under insect proof net house

S.No.	Crop	Planting time	Objectives of nursery raising
1.	Early cauliflower	May 20 – June 20 (By the use of 40% black shade net)	Production of a healthy nursery by reducing soil born problems
2.	Tomato	June 15 – July 15	Production of a virus-free healthy nursery
3.	Chilli	June 15 – July 15	Production of a virus-free healthy nursery
4.	Capsicum	August 15 – September 15	Production of a virus-free healthy nursery
5.	Tomato, chilli brinjal	December 15-30	Production of a healthy nursery by protecting against frost in winters
6.	Cucurbits	December 25 – January 10	Off-season production of a nursery by the use of plug tray technology

Economic analysis of nursery production in 50 m^2 net house

One time expected nursery production (plants)	=	5,000
Six times expected nursery production (plants)	=	30,000
Six times expected cost of production (₹)	=	6,000
Total expected income through nursery production (₹)	=	15,000
Expected net profit through nursery production (₹)	=	9,000

Healthy nursery production by reducing soil borne diseases

Zero energy naturally ventilated greenhouse technology

Zero energy naturally ventilated greenhouse is a special structure, made of G.I. pipes, insect proof nets and transparent plastic sheets, which protect the crops from adverse climatic conditions, insects, pests, and different viruses. All four sides of the greenhouse from the ground (8 to 9 feet height) are covered with an insect proof net, and rollable plastic curtains are used over the side nets. During the summer, all side curtains are rolled upward from all sides in the green house to maintain natural ventilation. The basic cost of fabrication of this kind of greenhouse is approximately ₹ 650/- per square metre. This kind of greenhouse does not require electricity. Mostly low pressure drip irrigation system is used. This type of greenhouse is suitable for growing vegetables in peri-urban areas. The roof is covered by a 180-200 micron thickness transparent plastic film. An insect proof nylon net is also used in place of roof ventilators. The major high-value vegetables grown under this kind of green house are, tomato and parthenocarpic cucumber varieties.

Optimum size and cost of green house

Optimum size of green house : 1000 m^2

Expected cost of fabrication : 6.50 lakh

Design of green house : Saw-tooth

System of irrigation : Low pressure drip system

Economics of tomato cultivation in green house

Crop duration	:	Mid July to end of April
Suitable varieties	:	GS-600 and Himsona
First harvesting of fruits	:	Mid October
Last harvesting of fruits	:	End of April
Expected fruit yield	:	15 tonnes per 1000 m^2
Total cost of crop production	:	₹ 90,000/-
Expected gross income (15 x 1500)	:	₹ 2, 25,000/-
Expected net return	:	₹ 1, 35,000/-
Expected cost benefit ratio	:	1 : 2.50

Note: Pusa Cherry 1, variety of cherry tomato, developed by the Institute, has the yield capacity of 2.5 – 3.0 t/1000 m^2 area of green house during 9-10 months of the year and the quality of fruits is very good.

Economics of seedless cucumber cultivation in green house

Crop duration	:	Mid July to end of April (3 crops) 1st crop – mid July to mid October 2nd crop – mid October to mid February 3rd crop – mid February to end of April
Suitable varieties	:	Kian for summer and Satis for winter
First harvesting of fruits	:	30 to 35 days after planting of each crop
Expected fruit yield	:	12 tonnes per 1000 m^2 (3 crops)
Total cost of crop production	:	₹ 1, 20,000/-
Expected gross income (20 x 1200 m^2)	:	₹ 2, 40,000/-
Expected net return	:	₹ 1, 20,000/-
Expected cost benefit ratio	:	1 : 2

Capsicum and tomato crops under zero energy naturally ventilated green house

Zero energy naturally ventilated green houses with low pressure drip system

Seed Production

Hybrid seed production in tomato

Hybrid tomato is produced through hand emasculation and pollination. Some of the promising hybrids released by the Institute for northern India are: Pusa Hybrid 1, Pusa Hybrid 2, Pusa Hybrid 4 and Pusa Hybrid 8.

Seed production technology

Sowing: The sowing should be completed by 15th October. Seedlings are ready for transplanting at 4-5 leaf stage (after 25-30 days of sowing). A planting ratio of one male for every four female plants is recommended.

Spacing: Male lines are planted in a different block to facilitate operations and avoid shading from competing plants. The 25-30 days old seedlings of male and female lines are planted on ridges (raised beds) formed at 90 cm apart. Plant to plant spacing of 60 cm is sufficient for maximum flower production per unit area.

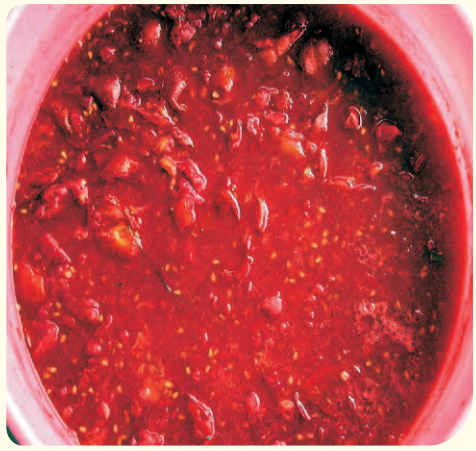
Emasculation procedure: The female flower must be pollinated by the pollen from the male line. To prevent self-pollination, remove the stamens from the flower buds of the female line before they shed their pollen. This process is called emasculation. Emasculation begins about 55-65 days after sowing when the night temperature is above 12^{o}C. Sharp-pointed forceps are used to force open the selected buds. The anthers, which are fused to form a cone like structure around the stigma, are removed by holding the flower bud in the left hand and forceps in the right hand. To help identify the hybrid fruits from selfed fruits at the time of harvest, cut the corolla and calyx (all or two sepals) of pollinated flower. Emasculation is generally done in the evening. In northern India, generally, the right time to undertake emasculation and pollination is between 15th January and 15th March.

Pollen collection: The best time for pollen collection is late evening (before the pollen has been shed). The anther cones are removed from the flowers and put in suitable containers, viz., petri dish or paper bags. Anther cones are dried by placing them 30 cm below a 100 watt lamp over night. Pollen can also be sun-dried. The dried anther cones are taken in a cup with a lid of fine mesh. Shake the cup about 10-20 times, so that the pollen is collected in the "lid" cup. The pollen can be stored for one day at moderate room temperature.

Emasculation of tomato

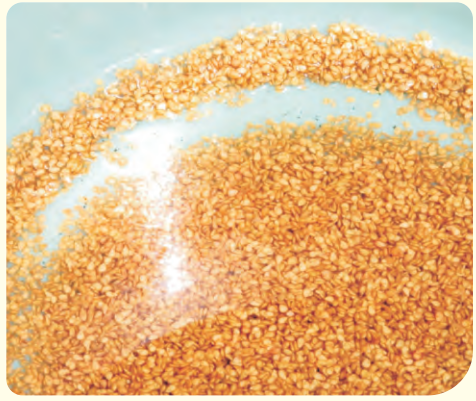
Pollination: Emasculated flowers are generally pollinated next day morning. The stigma is dipped into the pollen container or pollinated by touching the stigma with the tip of the needle dipped in the pollen pool. Successful pollination is easily seen within one week of pollination by the enlargement of the fruit. After crossing operations completed, any non-crossed flowers on the female plants are removed to lessen the chance of contamination from self pollinated seeds before harvest.

Harvesting: On an average, 50 or more fruits are retained on a female parent. Fruits start ripening after 50-60 days of pollination, but may take longer if the temperature is low. Harvest the fruits when they are in red ripe stage and are in full maturity. Fruits are collected in non-metallic containers such as polythene bags, plastic buckets or crates.



Seed extraction: The ripe fruits are crushed by trampling with hands. The bags of crushed fruits are kept in big plastic containers for fermentation and to separate the gel mass embedding the seeds. The time of fermentation (16-24 hr.) depends upon the ambient room temperature. Seeds are washed in an open plastic container filled with water and stirred to allow the pieces of flesh and skin sticking on the seeds to float. By inclining the container, the floating materials are removed, making sure that the seeds remain at the bottom. Repeat the washing several times, adding fresh water to the container every time until all the flesh and gel are completely removed, leaving clean seeds at the bottom.

Seed drying: Drying should be done in shade for three to four days. Stir the seeds two to three times daily to dry uniformly. The seed moisture would be maintained up to 6-8% through these processes.



Drying of tomato seeds

Seed yield: With good management practices, yield of 3-3.5 kg hybrid seed/100 m^2 can be obtained with a market value of about ₹ 20,000 per kg.

Hybrid seed production technology of brinjal

The Institute has developed and released three brinjal hybrids, namely Pusa Hybrid 5 (long fruited), Pusa Hybrid 6 and Pusa Hybrid 9 (round fruited) for cultivation in north Indian plains. *Kharif* season is best for their seed production. Hybrid seed production is done by hand emasculation and pollination.

Seed production technology

Isolation distance: Seed production field should be isolated by 200 m from any commercial crop of brinjal. Male and female parental line blocks should be separated by 5 metres.

Seed source: Genetically pure and certified/authentic seeds of parental lines should be procured from the breeding institute, seed corporations, agricultural universities or seed companies.

Seed rate: 400 g/ha (female parent: 300 g and male parent: 100 g)

Seed bed preparation: Seeds should be treated with thiram (2.5 kg/ha) and sown on raised seed beds at a distance of 5- 6 cm.

Transplanting: One month old seedlings are transplanted around 15-20 July on flat beds. Male and female parental line blocks should be planted separately keeping 3/4 of the block for the female and 1/4 for male. Row to row and plant to plant spacing should be 100 cm and 90 cm, respectively.

Fertilizer application: 20-25 tonnes of FYM/ha or organic manure 120 kg Nitrogen (split application: 25% as basal, 25% at 30 DAS, 25% at 45 DAS, 25% at 60 DAS), 80 kg phosphorus and 80 kg potash as basal application.

Irrigation: Field should be irrigated immediately after transplanting and at an interval of 15-20 days.

Roguing: Roguing should be done before flowering, during flowering and after flowering to remove off-types, diseased and undesirable plants.

Emasculation and pollination for hybrid seed production: Brinjal is a highly self-pollinated crop. Flowers are borne in bunches in primary, secondary and tertiary branches. There are three types of flowers: long styled, medium styled and short styled depending on the length of style. Flowers are open in the morning and pollination occurs between 7 A.M. and 10 A.M. Temperature and RH have immense bearing on the pattern of flowering and pollination behavior.

Hybrid seed production

Emasculation and pollination should be initiated two months after transplanting, i.e., 10-12 days after flower initiation in female parent. All opened flowers, flower bunches and self pollinated fruits should be removed from female parent from time to time and only hybrid fruits should be retained on the female plant.

Matured bud for emasculation

Healthy, solitary, long styled flowers, which are in balloon shape, should be selected for emasculation. Emasculation should be done in the evening by removing the anthers from flowers by forceps, and covering the flowers with butter paper soon after. Unopened male flowers, which will open next day, should be covered with cotton to prevent contamination and used for pollination.

Pollination of emasculated buds should be done next day in the morning between 7 A.M. and 9 A.M. Pollens are removed from covered male flowers of healthy anthers, with forceps and dusted on the selected female flowers. Although stigma remains receptive for 3 days, the maximum setting occurs when pollination is done on the next day of emasculation. Pollinated flowers should be covered with butter paper and labelled for identification and easy harvesting.

Emasculation process

Fruit setting: Maximum fruit and seed setting is achieved in flowers crossed between 15th September and 15th October.

Fruit retention: 5-6 fruits in round fruit types (PH 6, PH 9), and 9-10 fruits in long fruit types (PH 5), should be retained for higher seed yield and quality.

Harvesting: Harvesting of hybrid fruits should be done 65-75 days after pollination, when the fruits turn yellow, light purple or ochra brown and at least 4-5 times.

Seed extraction: Fruits are cut into four halves and beaten with wooden block, followed by thorough washing and drying.

Seed yield: 200-250 seeds/fruit (round type)
300-350 seeds/fruit (long type)

With good management, a yield of 2 kg hybrid seeds/100 m^2, having a market value of about ₹ 16,000 per kg can be obtained.

Emasculated bud

Hybrid seed production of cauliflower

Hybrid seed production technology for cauliflower hybrid, Pusa Kartik Sankar has been standardized for Delhi and adjoining areas.

Seed production technology

Sowing time	:	First half of July
Isolation requirement	:	1000 metres
Nursery preparation	:	Raised beds 15cm Width of beds < 60cm Covering of nursery with shade net/shirkis, FYM 10 kg/m^2
Nursery bed treatment	:	With Formaldehyde about 2 weeks before sowing and 0.3% solution of Thiram (5 litres/m^2) before seed sowing
Seed treatment	:	Thiram 3 g/kg seed Bavistin 2 g/kg seed
Seed rate	:	Female line 300-450 g/ha Male line 150-200 g/ha
Sowing of seeds	:	In furrows, 7-8 cm apart
Depth of sowing	:	1.5-2.0 cm
Transplanting time	:	First half of August
Planting ratio	:	4 : 2 (female: male)
Spacing	:	Row to row 60 cm Plant to plant 45 cm
Manure & Fertilizer	:	FYM 40-70 t/ha NPK 120 : 60 : 60 kg/ha Boron deficiency Borax @ 1-1.5kg/ha Molybdenum deficiency Spray Sodium or Ammonium molybdate @ 0.5-1 kg /ha
Intercultural operations	:	Regular earthing up
Irrigation	:	Frequent light irrigation till pod setting
Rouging	:	Reject/remove curds with blind, deformed & diseased plants, remove loose, ricey and fuzzy buttons and remove off-types after bolting but before flowering - Reject all early and late bolters - Select plants with uniform and peripheral bolting only
Application of chemicals	:	Spray GA_3 @ 250 ppm at bud initiation (BI) stage or IAA @ 100 ppm each at Curd maturity + Bolting + BI stages on female parent plants
Honey beehives	:	Keep 2-4 bee-hives/acre
Harvesting	:	Male line plants should be removed from the field once flowering is completed. The female line plants are harvested, when pods mature and attain yellow colour
Seed yield	:	200-300 kg/ha
Gross income	:	₹ 8,00,000-12,00,000/ha (Hybrid seed cost ₹ 4,000/kg)

Seed sowing in nursery

Pusa Kartik Sankar

Hybrid cauliflower seed production plot at curd initiation

Value Addition of Fruits and Vegetables

Various technologies have been developed for reducing the loss, for value addition and for enhancing the export of horticultural crops, cereal, pulse, and oil seed crops after harvesting. Details of these technologies are given below:

Developed technology & standardization

Ripe mango powder–to combat vitamin-A deficiency

Various types of product can be made from Mango pulp. The technology for making Ripe Mango Powder by drying ripe mango pulp has been developed by the Institute which is very suitable to combat vitamin A deficiency.

Process

Ripe mango
↓
Washing
↓
Peeling
↓
Slicing
↓
Heating in sugar 40°B, 0.1% KMS for 3 minutes
↓
Drying in cabinet dryer
↓
Grinding
↓
Sieving (30 mesh sieve)
↓
Packaging
↓
storage

Uses

- Mango ice-cream
- Baby foods
- Beverages
- Mango yoghurt
- Mango lassi
- Mango shake
- Fruit flavoured milk
- Ready-to-eat mango cereals
- Good adjunct in the ice cream industry

Ripe mango powder

Pusa fruit drinks – elixir of life

At the time of higher production of fruits, prices are very less in the market. To combat this situation, more income can be generated by making Pusa fruit drinks. The qualities of these drinks are as below:

- No synthetic colour or flavour
- Absolutely safe even for small children
- Products are made from fresh harvests of Pusa Institute farms
- Prepared under strict supervision and guidance of scientists for quality assurance by using GMP and HACCP products
- Contains natural antioxidants, vitamins and minerals
- The Institute provides entrepreneurship development training to prepare fruit drinks.

Jamun drink

Aonla drink

Ready-to-use *jowar* product

Technology for preparing ready-to-use products from *jowar*

Sorghum grains

↓

Lime treatment (0.5-1.0 %)
Washing (2-3 times with tap water)

↓

Hydration
(100 °C, 10 minutes)

↓

Cooling
(under ambient condition for 5 minutes)

↓

Flaking

↓

Drying (under fan, 1 h)

↓

Flaked grain

Benefits

- Instant nutrition
- Long keeping quality
- Easy preparation

Flaked jowar

Antioxidant rich functional food from *aonla*

Aonla is a health improving fruit, which has high medicinal value. Anti-oxidant rich *aonla* products can be prepared from fresh fruits.

Antioxidant rich *aonla* candy

Advantages

Healthy, nutritious and anti-oxidant-rich product: Coloured *aonla* candy for enhanced consumer appeal.

Fresh *aonla*

Saving post harvest losses of ginger through value addition

Process

Washing
↓
Peeling
↓
Slicing
↓
Pre-treatment
↓
Unit packaging
↓
Quick freezing
↓
Storage

Benefits

- Storage life: 6 months
- High oleoresin percentage
- Convenient
- Prevents post harvest losses

Frozen ginger slices

Pusa Zero Energy Cool Chamber

Fruits and vegetables, because of their high moisture content, are liable to spoilage. The spoilage of fruits and vegetables can be controlled by reducing the storage temperature. Pusa Zero Energy Cool Chamber, an on-farm storage chamber, developed by the Institute, has been found to be very useful and economical to save losses of fruits and vegetables after harvest. The details are as follows:

Pusa Zero Energy Cool Chamber-To reduce post-harvest losses of fruits and vegetables in storage

Comparative details of fruit storage

Storage life of fruits and vegetables (days)

Crops	Cool chamber	Normal condition
Mango	09	06
Banana	20	14
Lime	25	11
Tomato	14	07
Amaranth	03	01
Methi	10	03

Benefits

- Keeps fruits and vegetables fresh
- Retains nutritive value of fruits and vegetables
- No need of electricity
- Maintains low temperature and high relative humidity
- Can be used for mushroom cultivation and to store bio-fertilizers
- Saves post harvest losses
- Cost of construction (approx.): ₹ 3,000-3,500/- for a 100 kg capacity chamber

Pusa Zero Energy Cool Chamber

Apiculture

Apis mellifera

There are three species of true honeybee and three species of stingless bee native to India. Several sub-species and races of honeybees are also known to exist. The exotic honey bee, *Apis mellifera,* introduced during the sixties of the last century, has established well in our country. Together, they represent a wide variety of bee fauna, that can be utilized for the development of honey industry in the country. They are: *Apis florea*, the little bee; *Apis cerana indica*, the common Indian bee; *Apis dorsata,* the giant bee; and *Trigona irridipennis*, the stingless bee. Besides these, there are many solitary bee species, such as *Bombus, Ceratina, Halictus*, etc. Out of all these, only *Apis cerana indica* and *Apis mellifera* can be domesticated.

Apis mellifera

The success of bee-keeping depends upon the understanding of biology and behavior of honeybees, proper management techniques and latest equipment for handling them. It is advised that a beginner should start with five hives, which can be gradually increased, to make the venture profitable. To start beekeeping with five hives, an initial investment of approximately ₹15,000 is required, which includes non-recurring expenditure of ₹12,000. The invested money in establishing an apiary is recovered by selling honey and other related products in the first year of bee-keeping.

Apis cerana indica

Requirements for setting up an apiary

Areas with abundant flowering plants, eg., forest sites, agricultural farms and fruit orchards are ideal for bee-keeping.

1. Installation of the apiary

It depends on a series of factors, which are given below:

Vegetation: An apiary is established in a zone, where nectar yielding flowers are abundant. Most of our evergreen or semi-evergreen forests, plantations, agricultural farms having crops like eucalyptus, shisham, pongamia, etc., orchards like litchi, citrus, mango, peach, plum, apricots, apple, and gardens can be selected as suitable sites for bee-keeping. When plenty of flowers are present, 4 colonies /hectare are recommended.

Water availability: Availability of water is necessary at the periphery of the apiary. The minimum water requirement is around 45ml/beehive/day during winter and 1000 ml/beehive/day during summer.

Bee hive in field

Orientation of the colonies: The best orientations are south, south-east and south-west functionally with the direction of winds. Excessive wind causes hindrance during the exit and entrance of bees to the colony.

Set up: The beehives are placed on horizontal stands. The colony must be isolated from the ground to avoid humidity. Ant pans should be placed below the legs of the stand to prevent ants from reaching the beehives. Distance between two apiaries should be three to four kilometers.

2. Bee-equipments

There are several types of indigenous and traditional hives including logs, clay pots, wall niches, baskets, and boxes of different sizes and shapes. In modern beekeeping, the combs are built on wooden frames that are moveable. This facilitates inspection and management of bee colonies. Three types of movable frame hives in common use are: the Newton type along with its standardized ISI version, the Jeolikote Village type and the Langstroth type. Besides the hives, the beekeepers need equipments and implements like hive stand, nucleus box , smoker, honey extractor, bee veil, apron and hand gloves for protection from bee-sting.

3. Basic steps for beekeeping

- Bee-keeping should be started with a single colony/ few colonies, which can be increased later with experience.
- Beehives should be kept in a place, which is not affected by strong winds, sun, and away from crowded places.
- A good source of water should be available nearby, especially during summer. Hives should be at least 6 - 10 feet apart and on stands.
- Ant pans should be used to prevent ants and other insects from reaching the hive.
- Hive entrance should preferably face east.
- Ground around hives should be kept free of grass, weeds, black ants, white ants, etc.
- Colonies should be protected from wasps, lizards, bee-eating birds, etc.
- Hives should not be opened too often.
- Bees should not be disturbed on cold, rainy or windy days and at night.

Cost and benefit from 20 bee colonies during 3 years

Ist year		IInd year		IIIrd year	
Expenditure		**Expenditure**		**Expenditure**	
No. of bee colonies =20		No. of bee colonies = 40		No. of bee colonies = 40	
Cost of 20 bee colonies	= ₹ 60,000	Cost of 35 empty boxes	= ₹ 10,500	Cost of 35 empty boxes	= ₹ 10,500
Cost of equipments & transportation	= ₹ 6,000	Cost of 30 kg CF sheets	= ₹ 9,000	Cost of 35 kg CF sheets	= ₹ 10,500
Cost of 20 empty boxes (@ ₹ 500/-)	= ₹ 10,000	Miscellaneous expenditure	= ₹ 2,000	Miscellaneous expenditure	= ₹ 4,000
Cost of 20 kg Comb Foundation (CF) sheets	= ₹ 6,000	**Total Expenditure**	**= ₹ 21,500**	**Total Expenditure**	**= ₹ 25,000**
Miscellaneous expenditure	= ₹ 1,000				
Total Expenditure	**= ₹ 83,000**				
Income		**Income**		**Income**	
Honey production = 750 kg		Honey production = 1500 kg		Honey production = 1600 kg	
Income from sale of honey (@ ₹ 70/- kg)	= ₹ 52,500	Income from sale of honey (@ ₹ 80/- kg)	= ₹ 1,20,000	Income from sale of honey (@ ₹ 80/- kg)	= ₹ 1,28,000
No. of additional colonies obtained from division =20		No. of additional colonies obtained from division =35		No. of additional colonies obtained from division =30	
Net income = (-) ₹ 30,500 + 20 colonies		Income from sale of 35 colonies	= ₹ 1,05,000	Income from sale of 30 colonies (@ ₹ 3,500 per box)	= ₹ 1,05,000
		Total income = ₹ 1,20,000 +1,05,000	= ₹ 2,25,000	Total income	= ₹ 2,33,000
		Net income = ₹ 2,25,000 - (30,500+21,500) ₹ 2,25,000 - 52,000= ₹ 1,73,000		**Net income = ₹ 2,08,000 + 40 bee colonies**	

Note:- The quantity of honey production depends upon the availability of flora and weather conditions. The income figure may vary according to the market price of honey.

Mushroom cultivation

Commercial production of mushroom started in India during 1971 with an annual production of about 100 tonnes which was increased to approximately 1,20,000 tonnes (2010). Button mushroom continues to have the largest share in the total production in the world.

Production technology

Cultivation season of different mushroom in northern Indian plains

- **October to March**-White button mushroom ***(Agaricus bisporus)***
- **September to February** -Shiitake mushroom ***(Lentinula edodes)***
- **May to July** - Paddy straw mushroom ***(Volvareilla* sp.*)***
- **Mid August to mid April**-Oyster mushroom ***(Pleurotus* sp.*)***
- **February to April** - Milky mushroom ***(Calocybe indica)***

Button mushroom

Temperature requirement for mycelial growth and fruiting of button mushroom is 22-25^{o}C and 14-18^{o}C respectively alongwith 80-85% relative humidity for mushroom growth. However, another species *A. bitoriquis* is grown commercially. The optimum temperature for mycelial growth and fruiting is 25-30^{o}C and 22-25^{o}C respectively. However, *A. bistorus* is recommended for button mushroom cultivation in northern India.

Cultivation of white button mushroom *(Agaricus bisporus):* White button mushroom is the most commonly grown mushroom in northern India during winter from October to mid March.

Raw materials & ingredients of compost: Different formulations have been given by different organizations/ workers/institutions for making the compost. The most common compost formulation is as given below:

Wheat straw/rice straw	250 kg
CAN (Calcium Ammonium Nitrate)	4 kg
Urea	3 kg
Muriate of potash	4 kg
Wheat bran/rice bran	20-25 kg
Gypsum	20 kg
Malathion	40 ml
Molasses	5 kg

Straw used for compost making should not be older than one year and should be dry.

Mushroom for marketing

Compost preparation: Compost can be prepared by using any one of the methods given below:

Long method: Spread wheat straw in a thin layer of 8-10 inches thickness over floor of the composting yard. Sprinkle water over the straw to wet the straw thoroughly. Mix urea, CAN, wheat bran and other ingredients, except malathion and gypsum in the pre-wetted straw. Heap the mixed straw into a pile with the help of stack mould of the size of 1.25 m width x 1-1.25 m height x adjustable length depending upon the quantity of straw. The entire pile is opened and spread over composting yard on 3rd or 4th day for at least 45-60 minutes. This process is called turning and is repeated every 3rd or 4th day. During 3rd or 4th turning, gypsum is added. Add malathion during 5th or 6th turning. Each turning should be uniform with thorough mixing of the straw. Open the pile after 6th turning and check the smell of ammonia. If it persists, remake the pile and leave it for another 2-3 days. In this way, compost will be ready in 21-24 days.

Mushroom house

Pasteurization method: Pasteurization is done in two phases. The first phase is completed in the composting yard, while the second phase is completed inside the pasteurization tunnel of bulk chamber with the help of steam for conditioning of the compost.

Phase-I: It involves wetting of the straw, followed by mixing of ingredients in the straw as in the long method. But in this case, turning is given after every 48 h (2 days). During 3rd turning or on 6th day, total amount of gypsum is added in the compost. Give 4th turning on 8th day, and fill the compost in pasteurization tunnel on 10th day.

Fully grown mushroom

Phase-2: In pasteurization tunnel, 48-50^{O}C is maintained for 2-3 days. With the flow of steam, the temperature of the tunnel is raised to 58-60^{O}C and maintained for 6 h. Fresh air is then allowed to come in through ventilation. Once the temperature of the tunnel cools down to 50-52^{O}C, it is maintained for 3 days. After this, the tunnel cools down to 25-28^{O}C. By this method, compost is prepared in 19-20 days and smells like fresh hay. Fully prepared compost is dark brown in colour, with no trace of ammonia and no unpleasant odour. Water content in the range of 68-70% in the compost is best for mushroom growth.

Filling of the compost: Fully prepared compost is spread over composting yard overnight. Next morning when its temperature comes down to 25-27 ^{O}C fill it in trays, racks or poly-bags (8"-10" thick layer) after thorough spawning. Mixing the mushroom seed or spawn in the compost is called as spawning. After filling, it is compressed lightly and leveled. Four racks can be made, one over the other. Lower rack must be 20-25 cm above the ground level, and is followed by 45-50 cm surface to surface distance racks. Use 160-170g of spawn (mushroom seed) per square metre area of the compost. In racks, surface spawning in a double layer can also be done. After spawning, cover the compost with old newspapers.

Spawn running: Maintain the temperature of the mushroom house between 22-26^{O}C and relative humidity between 80-85%. In these conditions, the compost surface is covered with white cottony growth of the mycelium within 14-15 days of spawning. This condition is called spawn run.

Casing: After the completion of spawn, run casing is done by removing the newspaper sheet from the racks or trays and thereafter covering it with 4-5 cm thick layer of casing mixture and sprinkling some water. Most common casing material used is a mixture of FYM + 2-3 years old spent compost (1:1 ratio) after chemical or steam sterilization. After casing, maintain the mushroom house at 24-25 ^{O}C for another 4-5 days. Within 4-5 days, white mycelium will spread in the casing soil, after which lower the temperature to 18^{O}C and maintain it between 14 and 18^{O}C during the rest of the fruiting period. Watering should be done as and when required to maintain the relative humidity between 80-85% throughout the cropping period. Under favourable conditions, fruiting will start after 15-20 days of casing. Within 4-5 days, pinhead will attain the shape of white buttons.

Harvesting: Harvesting is done when the cap size of mushroom is 3 - 4.5 cm diameter with the help of a knife or hand. Soil from the stem is removed with the help of knife. The yield in bag cultivation method is estimated to be 10-15 kg/100 kg of compost. With pasteurized compost, 16-20 kg of fresh mushroom can be harvested per 100 kg of compost in 6-8 weeks.

Stock of mushroom spawn

Ready mushroom

Storage and packaging

- At ambient temperature mushroom can be kept upto 24 hours and in cold storage conditions it can be stored upto 3-4 days.
- After harvesting wash in running water and immediately store at 5 ^{O}C.
- Packing of mushroom in 200 g or 500 g in polythene bags can be done.

Cost and profit in mushroom cultivation

Production : Average production 5 kg/day (Duration : mid November - mid March)

S.No.	Cost and profit	Amount (₹)
1.	Non-reccurring expenditure & fixed capital	40,000
2.	Fixed cost	3,000
3.	Recurring cost (compost, bags, labour, spawn, etc.)	22,000
4.	Total cost of mushroom production (2+3)	25,000
5.	Total income (500 kg @ ₹ 80 /kg)	40,000
6.	Net profit (5-4)	15,000
7.	Cost : benefit ratio	5:8 or 1: 1.6

6

Resource Conservation Technologies

Organic Manure

Enriched Compost

In India, about 1,600 lakh tonnes of rock phosphate (RP) deposits are available, mostly of low-grade (<20% P_2O_5), unsuitable for manufacturing P-fertilizers. They perform reasonably well in acid soils but need suitable modifications for direct use in neutral and slightly alkaline soils. Potassic fertilizers used in the country are also imported. The world's largest deposits of muscovite mica, a K-bearing mineral containing 9-10% K_2O, are distributed over a total area of about 4,000 km^2 in Munger district of Bihar and Koderma and Giridih districts of Jharkhand. Waste micas, which are generated in large quantities during cleaning of raw micas after their mining are dumped near mica-mines, which could be a source of K if modified by chemical and/or biological means. A new technology has been developed by the Institute to prepare enriched compost using low-grade RP, waste mica and crop residues.

Enriched compost

Method of Preparation of Enriched Compost

Raw materials (kg) required for preparation of one tonne of enriched compost

Quantity of biomass (crop residues/ biodegradable wastes)	Low-grade rock phosphate (18-20% P_2O_5)	Waste mica (9-10% K_2O)	Fresh cattle dung	Final wt. of matured enriched compost
1000	200	200	100	1000

Filling of trench or pit

Trench or pit is filled layer-wise (5-6 layers). Biodegradable organic materials like crop residues, farm wastes, animal feed wastes and tree leaves are spread on the floor of the trench (about 20 cm thick layer). A layer of RP, followed by waste mica, is then spread over biodegradable organic material. Cattle-dung is made into slurry by adding water, and this is sprinkled over RP and waste-mica layer. It is repeated 5-6 times till the whole pit is filled up. Moisture content is maintained throughout the composting period at 60% of water-holding capacity. Periodic turning (monthly interval) is done to provide aeration. Composting is continued for 4 months.

Quality of enriched compost

One tonne (1000 kg) of enriched compost will substitute about 14-15 kg of N, 50-60 kg of P_2O_5 and 25-30 kg of K_2O, respectively.

Advantages of enriched compost

1. Large quantities of crop residues, *viz.,* crop residues/stubbles may be recycled back to the field after converting them into quality manure.
2. Substantial amounts of rock phosphate and waste mica may be recycled in agriculture as sources of phosphorus and potassium for plant need leading to the utilization of indigenous mineral resources.
3. Huge amount of foreign exchange can be saved partly or wholly on import of costly P and K-fertilizers.

Price of enriched compost

The cost of enriched compost (₹ 7/kg) is cheaper than that of phosphorous as diammonium phosphate (₹ 16.22/kg) and potash as muriate of potash (₹ 7.43/kg).

Vermicomposting

Vermicomposting is the process of converting agro-waste into compost by using earthworms. It provides macro and micro nutrients that are necessary for the growth and development of crops. It is an ideal natural manure that improves the physical, chemical and biological characteristics of the soil.

Prepared vermicompost

Farm waste for vermicompoting

- Tow weeks old farm yard manure
- Fruits and vegetables waste
- Crop residue, weed etc.

Some common species of earthworms used for vermi-composting are:

- *Eisenia foetida* (Red worm)
- *Eudrilus eugeniae* (African nightcrawler)
- *Perionyx excavatus* (Blue worm)

Most common is Red worm *(Eisenia foetida)* that is clearly recognized by their alternating red and buff stripes. The worm has a wide range of temperature tolerance but prefers 20-25 ^{O}C for fast growth, and doubles its population within 2-3 months.

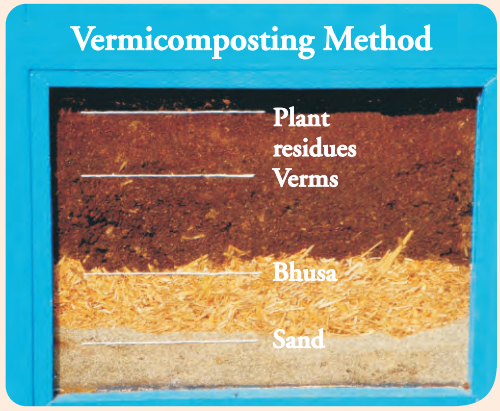
Eisenia foetida for vermicomposting

Production Technology

Prepare a bed as per space availability in shade and keep the following layers as follows:

1. First or bottom layer (1-2") is of sand or sandy soil.
2. Second layer (3-4") is of paddy or wheat straw.
3. Third layer (8-12") is of animal dung that is about 10-15 days old.
4. Fourth or top layer (4-6") is of agricultural waste.
5. Release mature earthworms @1000 worms per m^2 over the bed and cover it with gunny bags.
6. Sprinkle/spray water over the gunny bags so that bed moisture will be 40-60%. However, watering frequency varies according to the season: once a day in winter, 2-3 times a day during summer and once in 2-3 days during rainy season.
7. After 2-3 months, vermicompost develops the colour of used tea leaves, and is ready for harvest.
8. Stop sprinkling water over the pit/bed.
9. Collect, dry and sieve (using 2.5mm) the compost.
10. Collect earthworms and release again in new bed.
11. Pack the vermicompost in polythene bags and store in a shady place.
12. Two beds of 6 m x 1m produce one tonne of vermicompost.

Precaution: Bed should be located in a shady place at a higher plane and free from water stagnation.



Method of vermicomposting

Advantages & Uses of Vermicompost

1. In comparison to other fertilizers and organic manures, vermi-composting is very simple, prepared in lesser time, environmentally safe, and useful in increasing yield and making productive soils.
2. Vermicompost has microbes of various types, micronutrients, minerals (calcium, potassium, nitrogen), vitamins, enzymes and bacteria in ample quantities, which are essential for plants and to maintain the environment.
3. Provides proper environment to soil, water and microbes and conserve them.
4. There is no need of fertilizers, and soil fertility is regenerated by regular use of vermicompost.
5. The plants remain healthy, yield more and regenerated resistance against insects and diseases.
6. Vermicomposting is a simple, cheap and profitable enterprise which attracts youth for employment generation.
7. Recommended dose of application of vermicompost is as follows:

- For small plants @ 50-250 grams per plant
- For trees @ 1-10 kg/tree
- For field crops @ 5 tonnes/ha in first year and 2.5 tonnes/ha in second year and in subsequent years 1.5 tonnes/ha.

Vermicompost beds

Sparying of water on vermicompost beds

Constituents of Vermicompost

Organic Carbon	:	19.86 %
Nitrogen (N)	:	1.54 to 1.60 %
Phosphorus (P_2O_5)	:	1.29 to 1.33 %
Potash (K_2O)	:	0.86 to 0.95 %
Mineral content at 46 % moisture		
Ca	:	1.70 %
Mg	:	0.80 %
S	:	0.35 %
Zn	:	158 ppm
Cu	:	28 ppm
Fe	:	7497 ppm
Mn	:	257 ppm

Zero–tillage technology

- Experiences from several locations in the Indo-Gangetic plains have shown that with zero-tillage technology, farmers can save on land preparation costs by about ₹ 2500 per hectare and reduce diesel consumption by 50-60 litres per hectare.
- Zero–tillage is promising for *rabi* season crops like wheat, mustard, chickpea and linseed. Perfect land levelling, efficient seeding machinery, efficient weed management, optimum soil moisture, fertilizer management and pest control are essential for the success of zero- tillage technology.

Happy seeder for sowing under zero-till residue retention situation

- Retention of crop residues on soil surface is most essential for long-term success of zero-tillage system. Modern seeding machines, such as happy seeder, turbo seeder, double disc drill and roto-double disc planter are necessary for sowing in residue conditions.

Nitrogen economy through summer legumes in cereal-based cropping systems

- Nitrogen is saved to the extent of 60-70 kg/ha with *Sesbania*, and 40-50 kg/ha with cowpea and green gram in cereal-based cropping systems.
- Under summer legumes, there is an improvement in soil organic C and available N along with increased fixation of atmospheric nitrogen in the soil. Cultivation of dual-purpose legumes like green gram and cowpea during summer is better than *Sesbania* green manuring or fallow for improving the productivity, profitability, N economy and soil fertility in cereal-based cropping systems.

Bed planting technology for enhancing crop productivity

- Bed planting is a promising technique of crop establishment during *kharif* season. It increases the productivity of crops like pigeonpea, green gram, soybean, cowpea, etc., which are grown in *kharif* and prone to water logging.
- Raised bed planting increases grain yield and economic returns; improves resource use efficiency and reduces weed problem in soybean.
- Bed planting increases water economy in *rabi* crops by reducing irrigation water by 20%. It also reduces the seed requirement for sowing.

A view of bed planted soybean

Higher income through diversification in rice-wheat cropping system

- By rice-wheat-mungbean or rice-potato-mungbean cropping system, an increase of 12-15% in total productivity and a net profit of ₹ 15,000 to 22,000/ha can be obtained as compared to rice-wheat cropping system.

Use of zinc coated urea in rice-wheat cropping system

- In rice-wheat cropping system, 2.0% zinc sulphate-coated urea is better than 1.5% zinc sulphate or 2.0% zinc oxide coated urea and all these zinc treatments are superior to uncoated urea alone.

Improved yield and nitrogen use efficiency through neem oil coated urea

- Nitrogen use efficiency in transplanted rice is generally less than 40%, causing reduction in yield, wasteful use of N fertilizer and pollution of air and water. The nitrogen use efficiency and yield of rice can be substantially enhanced by using neem coated urea.
- Coating of prilled urea (PU) with neem oil (@ 1000 mg neem oil/kg PU) is beneficial in increasing grain yield, yield attributes, agronomic efficiency and apparent nitrogen recovery of rice. Application of 122 kg N/ha is optimum for aromatic varieties of rice under lowland irrigated situations.

A view of rice crop grown with neem oil coated urea

Use of plant growth promoting rhizobacteria (PGPR) to increase yield of rice hybrids

- The nitrogen requirement of hybrid rice is relatively higher than that of high yielding varieties. Bacteria such as *Azospirillum brasilense* and *Bacillus subtilis*, living in the vicinity of plant roots (rhizobacteria), may promote the growth of rice plants besides fixing N and suppressing plant diseases. The rice seed or seedlings can be inoculated with the culture of these PGPRs.
- Rice hybrids KRH 2, Arize 6444 and PHB 71 are suitable to be grown by system of rice intensification (SRI). The inoculation of rice with *Azospirillum brasilense* increases the grain yield of hybrid rice by 10-15%.

A view of rice crop grown with PGPRs, PGPR I (left) and PGPR II (right)

Use of bio-fertilizers with rock phosphate and single super phosphate

- The highest grain yield of wheat can be obtained with the application of 30 kg P through single super phosphate with phosphate solubilizing bacteria (PSB) and vesicular arbuscular mycorrhizae (VAM) or application of 30 kg P through rock phosphate with PSB and VAM.
- Higher root length, root volume and root dry weight in wheat can be obtained with full dose of P through single super phosphate without biofertilizer or half dose of P through single super phosphate with VAM or VAM+PSB or half dose of P through rock phosphate + PSB+VAM.

Rabi maize based diversification and inter cropping

- *Rabi* maize-mungbean-*kharif* maize or *rabi* maize-mungbean/toria-baby corn cropping system, can cause an increase of 6-7 tonnes/ha in total productivity and a net profit of ₹ 10,000-15,000 can be obtained as compared to maize-maize cropping system.
- Intercropping of radish is more profitable in *rabi* maize and a net income of ₹ 40,000 can be obtained with this system.

Control of *Parthenium hysterophorus* through herbicidal and non-herbicidal products in non-cropped areas

- 100 per cent control of *Parthenium* can be achieved with the application of metribuzin (70% WP) at 1.0-1.5 kg a.i. per hectare within two weeks
- Control of *Parthenium* in non cropped areas can also be achieved with a spray of 10 % urea or common salt solution.

A view of *Parthenium* weed

Weed management in onion

- In onion, sequential application of pendimethalin @ 0.75 kg/ha as pre-emergence followed by broadcasting pendimethalin @ 0.75 kg/ha (sand mix) 30 days after transplanting (DATP) is as effective as 3 hand weedings at 20, 40, and 60 days after transplanting and an income of ₹ 1,37,000/ha can be obtained.

Herbicide tank-mixes for higher weed control

- Tank-mixes are mixtures of two or more herbicides in the spray tank just before application. Tank mixes achieve greater weed control and lessen the possibility of spreading of various weed species.
- The tank-mix of fenoxaprop-p-ethyl + isoproturon (80 g/ha + 400 g/ha) or fenoxaprop + 2,4-D (80 g/ha + 250 g/ha) as post-emergence 30 days after sowing of wheat is highly effective in controlling broad-spectrum of weeds in wheat.
- The tank-mix of GA_3 (400 ppm) + pendimethalin (750 g/ha) + imazethapyr (100 g/ha) as pre-emergence is highly effective against composite weeds including *Cyperus rotundus* in soybean.

A view of sequential application of pendimethalin in onion crop

Soil solarization for weed control and higher yield

- Soil solarization is accomplished by covering soil surface with transparent polyethene film (50-100 mm thick). It raises the temperature of soil by trapping solar radiation inside to a level lethal to weed seeds and many soil-borne micro-organisms.
- It is adopted as a pre-planting treatment and employed during hot summer months (May-June).
- Soil solarization for four weeks during May-June increases the yields of soybean and brinjal over non-solarized fields.

Solarized soil | Soyabean in solarized soil | Soyabean without weed control

Controlling *Phalaris minor* in wheat

- Low-dose new herbicides like sulfosulfuron (30 g/ha), clodinafop-propargyl (60 g/ha), fenoxaprop-p-ethyl (100 g/ha) and metribuzin (150 g/ha) have been recommended as promising alternative herbicides for controlling resistant biotypes of *Phalaris minor* in wheat.

Technology for increasing productivity by intercropping in rapeseed-mustard

- African mustard/Indian mustard based intercropping systems with potato (1:3 replacement series), wheat (1:4 or 1:6), linseed (1:6), and chickpea (1:4 or 2:8) are more productive and profitable than their sole stand. African mustard at 90 cm + 2 rows of peas, coriander, fenugreek or radish are more productive and remunerative compared to their sole stand.

A view of mustard-chickpea intercropping

Comparative performance of *Bt* and non-*Bt* hybrids

- *Bt* hybrids, viz., RCH 134 and MRC 6304, on an average produce 1.0 t/ha of seed cotton and ₹ 19,630/ha higher net returns than non-*Bt* hybrid LHH 144.

Production technology for soybean

- Application of 30 kg N, 33 kg P, 23.2 kg K and 5 kg zinc/ha along with 5 t/ha each of crop residues and farmyard manure is optimum for both soybean and wheat in sequential cropping system.
- Application of 30 kg sulphur and 2 kg boron/ha in soils low in sulphur and boron, gives higher grain yield and monetary returns from soybean-wheat cropping system.

Technique to Raise Direct Seeded Puddled Rice

Variety of Rice : Pusa RH-10

Method of sowing

1. Direct seeding in lines under puddled condition : 14th June
2. Broadcasting under puddled condition : 14th June
3. SRI (age of nursery seedlings 14 days): in square planting 25 cm x 25 cm : 28th June
4. Conventional transplanting: 21-25 days old seedlings are transplanted at 20 cm x15 cm spacing

Direct seeding in lines

Seed at the rate of 12.5 kg/ha is soaked in water for 24 hours and sown directly in lines at 25 cm under puddled conditions.

Broadcasting under puddled conditions

Seeds at the rate of 12.5 kg/ha are soaked in water for 24 hours and after draining excess water, seeds are kept in moist gunny bags for 48 hours for sprouting. Seeds are mixed with equal amount of sand and graded FYM and broadcasted uniformly on the puddled plots.

System of rice intensification method

Nursery of PRH-10 is raised on raised beds covered with gunny bag having 3 kg FYM on it, 5 kg below the gunny bag, NPK 200 g and Zinc 25 g. Sprouted seeds @ of 12.5 kg/ha are spread on gunny bags and watered. For SRI, 14 days old seedlings are transplanted at 25 cm x 25 cm spacing.

Conventional method

For conventional transplanting, 21-25 days old seedlings are transplanted at 20 cm x15 cm spacing.

Fertilizer application

Apply fertilizers @ 120 kg N/ha, 60 kg P_2O_5/ha, 30 kg K_2O/ha, 25 kg zinc sulphate/ha. Apply 25% N and whole amount of phosphorus, potash and zinc at the time of last puddling. Top dressing of remaining nitrogen in two equal splits at 20 and 35 days after transplanting.

Weed management

Pre-emergence application of Pyrozosulfuron (10% EC) @ 25 g/ha two days after seeding/transplanting or Pretilachlor (50% EC) @ 750 ml/ha followed by one hand weeding 30-35 days after seeding/transplanting to keep the crop free from weed competition.

Irrigation

In direct seeded condition, gentle irrigation is given when greening has started (after 7-8 days) so that seeds are not disturbed and do not rot in standing water. Thereafter, crop is irrigated at 3-4 days interval throughout. In the transplanted rice, both under SRI and conventional method, water is allowed to stand for first fifteen days to improve crop establishment and to improve the efficiency of applied herbicide. Thereafter, irrigation is given two days after disappearance of standing water. In both the cases, irrigation is stopped 15 days before harvesting.

Flowering behavior

Direct seeded rice, both in rows and broadcasting, flowered in 69-72 days compared to 80- 93 days after seeding in SRI and conventional method, respectively.

Crop duration

Total duration of crop was 101, 100, 111, 120 days in direct seeded in lines, broadcast, SRI and conventional methods, respectively. Direct seeded rice advanced by 11 to 20 days compared to other methods.

Seed yield

Under direct seeded rice and SRI, seed yield was 29.5% and 17.6% respectively, higher than that of conventional method.

Technique for Raising Healthy and Weed Free Paddy Nursery

Field and bed preparation for nursery

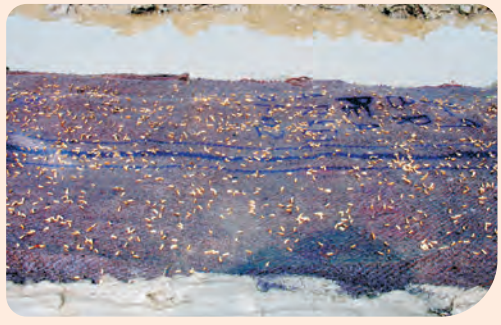
A new technique of raising nursery on old gunny bags has been evolved for the production of robust and weed free paddy nursery. After harvesting the wheat in the month of May, field is irrigated and in standing water broadcasting of *dhaincha* seed @ 5 kg/ha is done. After 50-60 days plough back the *dhaincha* crop in soil. The nursery area should be ploughed 3-4 times to obtain a fine tilth with harrow and cultivator followed by planking for uniform leveling.

Germinated paddy seeds

Weed free paddy nursery on jute gunny bags

Preparation of nursery bed: For transplanting one hectare, 250 m^2 net nursery area is sufficient .

Nursery area for seed sowing	**Total area**
With channels	500 m^2
Without channel	250 m^2
Number of beds	20
Length and breadth of nursery bed	20 m x 0.6 m
Space between two nursery beds	0.6 m (for irrigation)
Size of jute bag	0.6 m x 2.0 m
Number of bags/nursery bed	10
Seed required/nursery bed	600 g (12.5 kg/ha)
Fertilizer/nursery bed	Ground FYM 3.0 kg on gunny bags; 5.0 kg FYM + 200 g NPK and 25 g zinc sulphate below the gunny bag



Broadcasting of germinated paddy seeds on nursery beds covered with gunny bags

Seed treatment

- For transplanting one hectare, 12.5 kg paddy seed is soaked in solution of 1 g streptocycline + 25 g bavistin in 20 litres of water for 12-18 hours.
- Further, seeds are kept for incubation in the wet gunny bags, after draining excess water, for 24 hours to allow sprouting. Moisture should be maintained in gunny bags.

Sowing and after care

- Nursery beds of 0.6 m breadth and 20.0 m length and 2-3" height are prepared.
- On the nursery bed 5.0 kg FYM + 200 g NPK and 25 g zinc sulphate is evenly spread.
- Covered with wet gunny bags.
- Sprouted seeds are uniformly distributed on the gunny bags and are covered with ground FYM.
- Special care must be taken toward off the birds till seed germinates.
- For control of termites, chlorpyrifos @ 3.0 l/ha can be used at first/second irrigation. The seedlings are ready to transplant in 15 days after sowing (DAS) through this method.

Advantages

- Gunny bags serve as impediment to weeds and do not allow them to emerge and thus, seedlings are weed free.
- Uprooting time is reduced to half, which reduces labour requirement and expenditure on weed control. No chance also to grow old paddy plants of last years crop.
- Gentle uprooting from gunny bags does not cause any mechanical injury to roots and reduces the risk of incidence of *bakanae* disease.

Use of decomposed cow dung manure on beds

Germinated paddy on gunny bags

Nursery sown on gunny bags

Weed Control : Application Techniques

In northern India, cucurbitaceous crops like musk melon, water melon, bottle gourd and bitter gourd are sown in the month of March. With the rise in temperature, these crops are predominantly infested with the troublesome and obnoxious weed of spring summer season i.e. purple nut sedge (*Cyperus rotundus*). Hand weeding fails to control *Cyperus rotundus* as under-ground rhizomes produce numerous chains of tubers. The Institute has developed a new application technique to control purple nut sedge, by using glyphosate, a new selective herbicide. In this technique, cucurbit plants at three to four leaf stage are covered with plastic pots having 8" diameter and 12" height. Individual plants should be fully covered with plastic pots and there after sprayed with 1% glyphosate [41%SL (100 ml glyphosate in 10 liters of water)]using 500 l/ ha solution.

Covering by plastic pots

Glyphosate is rapidly absorbed by foliage and is translocated to roots and other underground storage organs in sufficient quantities to kill the targeted plants.

Cyperus rotundus and other broad-leaf weeds start degeneration (yellowing) within 6 to 8 days. Glyphosate shows no residual soil activity upon contact with soil as it is bound by soil particles and is rapidly inactivated. It does not affect the crop plant.

Precautions during spraying

- Crop plant should be fully covered and should not come in direct contact with glyphosate.
- After the spraying, the pots must be allowed to dry, to avoid any herbicide droplet adhering to outer surface, before shifting to other place.
- Pots should not be stacked during shifting and must be carried individually.
- Glyphosate must be applied when weeds are green and actively growing.
- Unlined steel or galvanized steel drums or containers that react with glyphosate should not be used.

Spraying of glyphosate

Profitable Crop Rotations

Crops/cropping systems for rainfed/dryland regions in north-western plains

Crops/cropping systems	Yield (t/ha)	Sowing time	Harvesting time	Net returns (₹/ha)
Mono-cropping system				
***Kharif* crops**				
Pearl millet	1.8-2.0	July	October	8,000-10,000
Maize	2.0-2.2	July	October	10,000-12,000
Pigeonpea	1.2-1.5	June-July	December-January	25,000-35,000
Green gram/black gram/cowpea	0.8-1.0	July	September	16,000-22,000
Groundnut	1.2-1.5	July	October	15,000-22,000
Soybean	1.6-1.8	July	November	14,000-17,000
***Rabi* crops**				
Toria	0.7-0.8	September	December	8,000-10,000
Mustard	1.2-1.5	October	March	12,000-18,000
Taramira	0.7-0.8	October	March	5,000-8,000
Chickpea	1.2-1.5	October	March	16,000-22,000
Lentil	0.8-1.0	October	March	10,000-15,000
Linseed	0.8-1.0	October	March	6,000-9,000
Wheat	2.0-2.5	October-November	April	12,000-18,000
Intercropping system				
Pearl millet + green gram	1.2-1.5 + 0.3-0.4	July	October	10,000-12,000
Pigeonpea + green gram/ black gram/groundnut	1.0-1.2 + 0.3-0.4	July	December	32,000-40,000
Mustard + gram	0.4-0.6 + 0.8-1.0	October	March	16,000-20,000
Wheat + mustard	1.8-2.0 + 0.3-0.4	October	April	16,000-20,000
Mustard + lentil	0.4-0.6 + 0.6-0.8	October	March	14,000-20,000
Chickpea + linseed	0.8-1.0 + 0.4-0.5	October	March	14,000-20,000
Double cropping system				
● Green gram/black gram	0.8-1.0	July	September	26,000-36,000
Mustard	1.0-2.0	October	March	
● Maize	2.0-2.2	June end	September	18,000-23,000
Wheat/barley	1.5-1.8	October	April	
● Maize	2.0-2.2	June end	September	18,000-26,000
Mustard/chickpea	0.8-1.0	October	March	
● Pearl millet	1.8-2.0	July	September	15,000-20,000
Mustard/chickpea	0.8-1.0	October	March	

Cropping systems for irrigated areas of Indo-Gangetic plains

Crops/cropping systems	Yield (t/ha)	Sowing time	Harvesting time	Net returns (₹/ha)
Double cropping system				
• Basmati rice	3.5-4.0	June / July	October	70,000-90,000
Wheat	4.0-4.5	November	April	
• Basmati rice	3.5-4.0	June / July	November	80,000-95,000
Sunflower	2.0-2.2	February	May	
• Rice	5.0-6.0	June / July	October	65,000-80,000
Wheat	4.5-5.0	November	April	
• Rice	5.0-6.0	June / July	October	70,000-95,000
Berseem (fodder + seed)	40-50 + 0.4-0.5	October	May	
• Maize	4.0-4.5	June	October	60,000-70,000
Wheat	4.5-5.0	November	April	
• Pigeonpea	1.8-2.0	June	November/December	75,000-85,000
Wheat	4.0-4.5	December	April	
• Cotton	2.0-2.5	May	November/December	60,000-80,000
Wheat	4.0-4.5	December	April	
• Groundnut	1.8-2.0	July	October	60,000-70,000
Wheat	4.5-5.0	November	April	
• Rice	5.0-6.0	June/July	October	45,000-60,000
Chickpea	1.2-1.5	October	April	
• Soybean	2.0-2.5	July	November	55,000-65,000
Wheat	4.5-5.0	November	April	
• Soybean	2.0-2.5	July	November	55,000-80,000
Potato	20-25	November	February	
Triple cropping system				
• Green manuring (Sesbania/sunnhemp/cowpea)		April	June	68,000-80,000
Rice	5.5-6.0	June/July	October	
Wheat	4.5-5.0	November	April	
• Fodder (cowpea + *bajra*/maize/*jowar*)	20-25	April	June	75,000-85,000
Maize	4.0-4.5	July	October	
Wheat	4.5-5.0	November	April	
• Green manuring (Sesbania/sunnhemp/cowpea)		April	June	64,000-75,000
Maize	4.5-5.0	July	October	
Wheat	4.5-5.0	November	April	

Crops/ cropping systems	Yield (t/ha)	Sowing time	Harvesting time	Net returns (₹/ha)
● Maize	4.0-4.5	Mid June	September	75,000-95,000
Potato	18-20	September-end	December	
Wheat	3.5-4.0	December	April	
● Rice	5.0-6.0	June/July	September	70,000-95,000
Potato	15-18	September-end	December	
Wheat	3.5-4.0	December	April	
● Rice	5.0-6.0	July	October	85,000-1,05,000
Potato	20-22	October	January/February	
Green gram	0.8-1.0	March	June	
● Maize	4.5-5.0	July	October	1,00,000-1,30,000
Potato	25-30	October	January/February	
Green gram	0.8-1.0	March	June	
● Rice	5.0-6.0	June/July	October	85,000-1,10,000
Potato	15-18	October	January	
Sunflower	2.0-2.2	February	May	
● Rice	5.0-6.0	June	Mid-September	75,000-95,000
Toria/Mustard	0.8-1.2	September/October	January	
Sunflower	2.0-2.2	February	May	
● Rice	5.5-6.0	June/July	October	85,000-1,00,000
Wheat	4.5-5.0	November	April	
Green gram	0.8-1.0	April	June	
● Maize	4.5-5.0	July	October	80,000-1,00,000
Wheat	4.5-5.0	November	April	
Green gram	0.8-1.0	April	June	
● Maize	4.0-4.5	June	September	1,15,000-1,45,000
Potato	25-30	October	January	
Sunflower	2.0-2.2	February	May	
● Maize	4.0-4.5	June	September	70,000-85,000
Toria/Mustard	0.8-1.2	September/October	January	
Sunflower	2.0-2.2	February	May	
● Maize	4.5-5.0	June	September	75,000-85,000
Mustard	2.0-2.2	October	March	
Green gram/Black gram	0.8-1.0	April	June	
● Rice	4.0-4.5	June/July	October	75,000-90,000
Mustard	1.8-2.0	October	March	
Green gram/Black gram	1.0-1.2	April	June	

Crops/ cropping systems	Yield (t/ha)	Sowing time	Harvesting time	Net returns (₹/ha)
• Maize	4.0-4.5	June	September	95,000-1,40,000
Potato	20-25	October	January	
Onion	20-25	January	April	

Quadruple cropping system

• Maize	4.0-4.5	Mid-June	September	1,00,000-1,10,000
Potato	20-25	September	December	
Wheat	3.5-4.0	December	April	
Greengram	0.6-0.8	April	June	
• Maize	4.0-4.5	Mid-June	September	95,000-1,00,000
Toria	0.6-0.8	September	December	
Wheat	3.5-4.0	December	April	
Green gram	0.6-0.8	April	June	
• Rice	5.0-6.0	Mid-June	September	1,10,000-1,12,000
Green peas	3.0-4.0	October	December	
Wheat	3.5-4.0	December	April	
Green gram	0.6-0.8	April	June	
• Maize	4.0-4.5	Mid-June	September	80,000-85,000
Radish / Turnip	18-22	September	November	
Wheat	3.5-4.0	November	April	
Green gram	0.6-0.8	April	June	

Cropping system related to vegetables in urban areas

• Brinjal	30-35	May-June	September-October	1,10,000-1,20,000
Methi	6.0-7.0	October-November	November-January	
Bottle gourd	18-20	February-March	April-June	
• *Broccoli*	18-20	October-November	January-February	1,20,000-1,30,000
Tomato	30-32	December-February	May-June	
Baby corn	1.5-1.8	July	August-September	
• Spinach	15-20	September-November	November-January	1,00,000-1,10,000
Onion	15-18	December-January	March-June	
Okra	8.0-10	June-July	August-November	
• Radish	20-22	September-October	December-January	1,30,000-1,40,000
Tomato	30-32	December-February	May-June	
Bottle gourd	18-20	June-July	August-September	

Vegetable based cropping system

Region	Cropping system	Yield (t/ha)	Net returns (₹/ha)
Northern plains	Early Cauliflower (July-October)	10-12	1,00,000-1,10,000
	Peas (October-January)	7-8	60,000-70,000
	Tomato (January-June)	40-45	1,20,000-1,40,000
	Okra (June-September)	12-14	50,000-65,000
	Carrot (October-December)	25-30	90,000-1,00,000
	Cauliflower (December-March)	25-30	37,000-52,000
	Radish (April-May)	15-18	36,000-40,000
	Cucumber (July-September)	12-13	90,000-1,00,000
	Potato (October-December)	16-18	60,000-70,000
	Onion (January-June)	22.5-25.0	1,10,000-1,30,000
North-eastern area	Cauliflower (June-August)	10-11	1,00,000-1,20,000
	Peas (September-November)	8-10	70,000-80,000
	Radish (December-January)	17-20	30,000-40,000
	Sweet pepper (January-May)	15-16	1,00,000-1,20,000
	Green Chilli (June-September)	11-12	42,000-50,000
	Broccoli (October-December)	11-12	90,000-1,00,000
	Radish (January-February)	15-16	30,000-33,000
	Bottle gourd (February-May)	30.0-32.5	50,000-58,000
North-western hills	French Bean (July-Stepmber)	10-11	60,000-70,000
	Knol khol (September-November)	15-16	50,000-55,000
	Peas (November-April)	10-11	75,000-80,000
	Sweet pepper (April-July)	15-16	1,50,000-1,65,000
	Tomato (June-September)	35-40	1,20,000-1,40,000
	Cabbage (September-November)	20-22	70,000-80,000
	Turnip (November-February)	20-21	30,000-33,000
	Potato (March-May)	25-30	80,000-1,00,000

Vegetable and cereal based cropping system

Cropping system	Yield (t/ha)	Net returns (₹/ha)
Basmati Rice (June-November)	3.5-4.0	45,000-55,000
Cauliflower (November-January)	25-30	37,000-52,000
Vegetable Cowpea (February-April)	7.0-8.0	20,000-25,000
Total returns		**1,02,000-1,32,000**
Basmati Rice (June-November)	3.5-4.0	45,000-55,000
Peas (November-March)	7.0-8.0	40,000-50,000
Bottle gourd (March-May)	30.0-32.5	50,000-58,000
Total returns		**1,35,000-1,63,000**
Basmati Rice (June-November)	3.5-4.0	45,000-55,000
Cauliflower (November-January)	25-30	37,000-52,000
Onion (January-May)	22.5-25.0	52,000-62,000
Total returns		**1,34,000-1,69,000**
Rice (June-September)	5.5-6.0	57,000-65,000
Carrot (September-December)	25-30	45,000-60,000
Wheat (December-April)	3.5-4.0	25,000-30,000
Total returns		**1,27,000-1,55,000**
Rice (June-September)	5.5-6.0	57,000-65,000
Cauliflower (September-December)	15-20	50,000-65,000
Wheat (December-April)	3.5-4.0	25,000-30,000
Total returns		**1,32,000-1,60,000**
Okra (June-September)	13-14	35,000-40,000
Radish (September-November)	15-20	25,000-40,000
Wheat (November-April)	4.5-5.0	35,000-40,000
Total returns		**95,000-1,20,000**
Brinjal (June-September)	35-40	70,000-90,000
Palak (September-November)	15.0-17.5	30,000-37,000
Wheat (November-April)	4.5-5.0	35,000-40,000
Total returns		**1,35,000-1,67,000**

Fruit crop based cropping system

Region	Cropping system	Yield (t/ha)	Net returns (₹/ha)
Northern plains	Papaya (October planting) +	37-45	95,000-1,20,000
	Wheat	1.8-2.5	10,000-16,000
	Maize	2.5-3.0	15,000-20,000
	Total returns		**1,20,000-1,56,000**
Eastern plains	Banana +	22-26	75,000-95,000
	Elephant foot yam +	12.0-14.5	45,000-55,000
	Turmeric	8.5-12.0	35,000-50,000
	Total returns		**1,55,000-2,00,000**
Medium hills of north-east and south	Banana +	12-15	38,000-45,000
	Pineapple +	14.0-18.5	28,000-36,000
	Ginger	7.5-10.5	30,000-40,000
	Total returns		**96,000-1,21,000**

Rhizobium

Rhizobium inoculants establish efficient symbiotic association with pulses, leguminous, oil-seed and fodder crops and thus, can fix 50 – 100 kg N/ha. A well nodulated legume crop also leaves sizeable amount of nitrogen in soil, which can meet a part of N-requirements of the succeeding crop in rotation. A 10-70 per cent increase in yield of crops due to inoculation with *rhizobium* inoculants over that of uninoculated control can be obtained depending on agro-climatic conditions, the variety planted and pest control measures used. Since *rhizobium* is specific to each legume, only recommended inoculant should be used for crops such as gram, lentil, pea, soybean, groundnut, *arhar*, *moong*, *urd*, cowpea, *berseem*, lucerne, *dhaincha* and sunnhemp.

Packets of *rhizobium* inoculant

Azotobacter

The use of *azotobacter* inoculants is recommended in crops like wheat, paddy, maize, barley, tomato, potato, cotton and mustard. *Azotobacter* fixes atmospheric nitrogen in soil and helps in saving chemical fertilizers by 15-20 kg N/ha. Besides this, it also secretes growth promoting substances, which helps in better seed germination and proliferation of roots, thus, improving nutrient availability for plants. *Azotobacter* suppresses the growth of some saprophytic and plant pathogenic microorganisms in rhizosphere and therefore, reduces the crop damage due to plant diseases. *Azotobacter* helps in maintaining better plant population, growth and improves yields of crops. In general, 10-20 % increase in grain yield over that of uninoculated control has been recorded due to inoculation with *azotobacter*.

Azotobacter inoculant

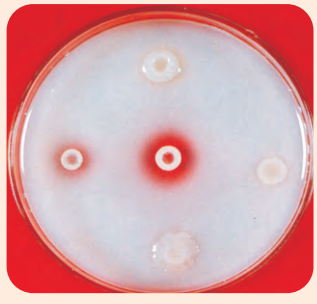
Azospirillum inoculant packet

Azospirillum

Azospirillum inoculants are recommended in non-leguminous crops like *jowar*, *bajra*, *ragi* and other millets like Italian millet, kodo millet, barn yard millet, small millet and oats. Increase in grain and fodder yield of millets due to its inoculation is almost equivalent to that attainable with 15-20 kg N/ha.

Phosphate solubilizing bacterial inoculants

Inoculation with an efficient P solubilizing micro organism improves the availability of phosphorus from insoluble form of phosphorus in soil and enhances the use-efficiency of phosphatic fertilizers such as super phosphate. Therefore, soil fixed phosphorus is effectively

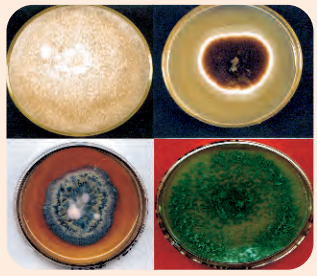

Solubilizing of phosphorus by micro bacteria

available to the crops, treated by these micro organisms. These have been tested for their potential in many crops such as wheat, paddy, cowpea, soybean, lentil, gram and potato all over India under field conditions. Increase in their grain yield was found in the range of 10-50%, and about 40% of super phosphate could be saved by combined application of rock phosphate and phospho-micro organisms.

Packet of phosphate solubilizing bacterial inoculants

Compost inoculants

A microbial inoculant, which is a consortium of several micro organisms has been developed for rapid composting of organic wastes. This inoculant is suitable for degradation of cellulose, hemi-cellulose and lignin and a packet containing 500 g of inoculant is sufficient to treat one tonne of agro-waste for rapid composting.


Improved microbial inoculants for composting

Arbuscular-Mycorrhiza (Nutrilink)

Arbuscular-Mycorrhizae (AM) are symbiotic associations between plant and a specific group of fungi. The hyphae of AM form a bridge between plant and soil and serve to cater to the requirements of plant nutrients, especially phosphorus and trace elements like zinc, iron, copper, cobalt, magnesium, molybdenum, etc. AM colonization in plant roots increases plant growth, improves nutrient availability and reduces salt stress. It also checks soil erosion, degradation and reduces losses caused by nematodes and plant pathogens. AM inoculant is recommended for sugarcane, potato, transplanted crops and orchard. This inoculant has also been found very useful in crops like coffee, tea, papaya, cocoa, oil palm, etc. Crops treated with AM inoculant show improvement in grain and fruit quality as well as in yield. 5.0 kg AM culture is sufficient for crops sown in one acre. Mixed AM in soil, FYM, compost or vermicompost in 1:20 ratio and apply near root zone.


AM production in earthen pot

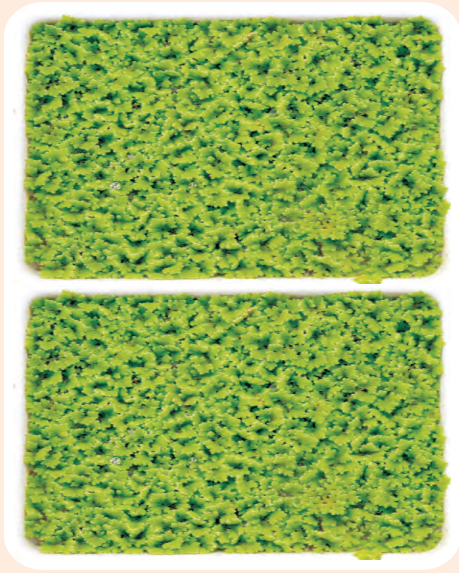
Blue-green Algae

For paddy cultivation, use of blue-green algal inoculant has been found beneficial. It provides not only nitrogen but also organic carbon and growth promoting substances. After long research and trials, the Institute has developed a consortium of selected cultures of BGA and made a clay based formulation to get maximum benefit in paddy cultivation. A 500 g packet of this inoculant is sufficient to inoculate one acre of paddy field and mix one packet of BGA in 4-5 kg soil and broadcast in standing water in paddy field. If chemical fertilizers are not used, BGA inoculant gives a benefit of 20-30 kg N/ha.

Packets of blue-green algae

Azolla

Azolla is a free-floating water fern having symbiotic association with *anabaena*. *Azolla* contributes 40-60 kg N/ha/crop in paddy depending upon the rate of its application. The important factor in using *azolla* as a biofertilizer for paddy is its quick multiplication and subsequent rapid decomposition in soil and efficient availability of nitrogen to the crop.



***Azolla* production in plastic tray**

Use of microbial inoculant/culture

Rhizobium, Azotobator, Azospirillum and PSB are used for seed treatment. One packet of 150-200 g biofertilizer is sufficient for seed to be sown in one acre.

Cost benefit ratio of biofertilizers

Biofertilizers	Rate of application (kg/ha)	Crops	Application method	Input cost (₹)	Impact kg/ha N/P	Total benefit (₹)	Anticipated benefits/ha
Rhizobium	0.5	Pulse and oilseed crops	Seed treatment	25	20.0	190-225 540-880	19-22 kg/ha (grain legumes) 50-80 kg/ha (fodder)
Azotobacter	0.5	Cereal and fodder crops, oilseeds & vegetables	Seed, seedlings & soil treatment	25	17.5	145-200	15-20 kg/ha
Azospirillum	0.5	Cereal and fodder crops	Seed treatment	25	20.0	200	20 kg/ha
BGA	1.0	Rice	Direct spray in soil	80	27.5	260-315	25-30 kg/ha
P-solubilizer (PSB)	0.5	All crops	Seed treatment	25	25.0	600	25 kg P_2O_5/ha
AM inoculant (VAM)	0.5	Horticultural nursery and all other crops	Direct spray in soil	100	25.0	420-670	20-30 kg P_2O_5/ha

N/p: Net profit

Cost benefit ratio of phospho-compost

Raw materials required for preparation of one tonne of phospho-compost (kg)

Raw materials	Quantity (kg)	Estimated cost (₹)
Crop residues	1500	–
Compost/FYM	200	600.00
Rock phosphate	50	250.00
Compost inoculant	500	20.00
	Total cost (₹)	870.00

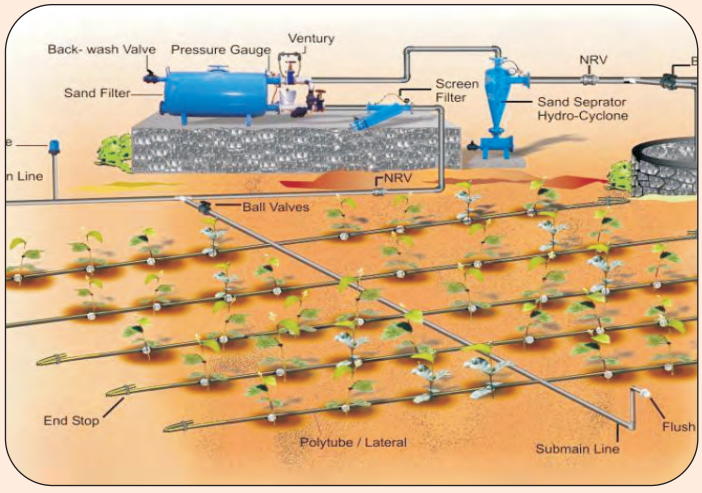
Market price of 1000 kg of phospho-compost @ ₹ 3/kg

Market price (1000x3)	:	₹ 3,000/-
Cost	:	₹ 870/-
Profit	:	₹ 2,130/-

Water Conservation Technology

Drip irrigation

Drip irrigation is a method of water application for irrigating plants at the root zone through emitters fitted on a network of pipes (mains, sub-mains and laterals). Well designed drip system would provide uniform, equal and adequate water to all plants in the field at a higher level of irrigation efficiency. The main advantage of drip irrigation system is its high degree of control on water application. Drip irrigation provides a large number of irrigating points per unit area that result in better uniformity of water application. By this irrigation system 30-40 % of fertilizer doses and 70 % of water can be saved and 90 % yield can be increased.



A typical drip irrigation system

Types of drip irrigation systems

1) Surface drip irrigation system

In surface system, the drippers and the lateral lines are laid on the soil surface. In this system, water is applied to the soil near the root zone of the plants. The system applies water slowly under pressure to maintain the soil moisture within the desired range of plant growth. The volume of soil wetted by surface drip irrigation is much less than that wetted by surface irrigation methods.

Drip irrigation in field crop

2) Sub-surface drip irrigation system

In sub-surface system, the laterals and the drippers are installed below the soil surface and water is applied slowly through drippers. The most commonly used systems are Bi-wall, Typhoon and T-tape Bi-wall systems. These systems are mostly used for irrigating row crops.

Drip irrigation components

A typical drip irrigation system has many components including:

(I) Head works consisting of control unit, filters and fertilizer applicators

(ii) Water distribution pipes network consisting of main, sub main and laterals

(iii) Water emitting devices

(iv) Flow regulating and flushing devices, and

(v) Automation unit and sensors: Depending upon the crop, size of the farm, quality of available water, application of chemicals and fertilizers with irrigation water, the need of automation unit is decided

Drip irrigation in field crop

Advantages of drip irrigation

- 40 % to 60 % of water can be saved over that of flood method. Runoff and deep percolation losses are negligible.
- Water use efficiency of drip irrigation is 90-95%.
- Labour is required only to start and stop the system.
- Weed infestation is very less or almost nil due to less wetting of soil.
- Saline water can be used. Frequent irrigation keeps the salt concentration within root zone soil below harmful level.
- Diseases and pest problems are relatively less because of less atmospheric humidity.
- Suitable under various soil physical constraints as flow rate can be controlled.
- Water control is very precise, high and easy.
- Fertilizer efficiency is very high due to reduced loss of nutrients through leaching and runoff water.
- Partial and controlled wetting of soil surface eliminates any possibility of soil erosion.
- Frequent watering eliminates moisture stress and yield can be increased from 20% to 100%.

Drip irrigation in cabbage

Suitable crops for drip irrigation

Orchard crops : Grapes, banana, pomegranate, orange, citrus, tamarind, mango, fig, lemon, custard apple, sapota, guava, pineapple, coconut, cashew, papaya, *aonla*, litchi, watermelon, muskmelon, etc.

Vegetables: Tomato, chilly, capsicum, cabbage, cauliflower, onion, okra, brinjal, bitter gourd, bottle gourd, ridge gourd, cucumber, peas, spinach, pumpkin, etc.

Cash Crops: Sugarcane, cotton, arecanut, strawberry, etc.

Flowers: Rose, carnation, gerbera, anthurium, orchids, jasmine, lily, mogra, tulip, dahlia, marigold, etc.

Plantation: Tea, rubber, coffee, coconut, etc.

Spices: Turmeric, cloves, mint, etc.

Oil seeds: Sunflower, oil palm, groundnut, etc.

Forest crops : Teak wood, bamboo, etc.

Limitations of drip irrigation systems

- Salinity hazard - in the long run, in the absence of leaching, salts build up.
- Sensitivity to clogging of system components.
- High cost of irrigation systems.
- Requirement of high skill in design, installation and operation.

Sprinkler irrigation

In order to increase the crop production in keeping with the population growth, more area of land is to be brought under irrigation. This is possible only by introducing the sprinkler system, replacing surface methods for certain crops and locations. In the sprinkler method of irrigation, water is sprayed into the air and allowed to fall on the ground surface. The spray is developed by the flow of water under pressure through small orifices and nozzles. The pressure is usually obtained by pumping. With careful selection of nozzle size, operating pressure of pump and sprinkler spacing, the amount of irrigation water required to refill the crop root zone can be applied nearly uniformly at a rate to suit the infiltration rate of the soil, thereby, obtaining efficient irrigation. Sprinkler irrigation is suitable for closely spaced crops like groundnut, cotton, sugarcane, millets, pulses, and forage crops. This method is becoming increasingly popular in India in the regions of water scarcity where water is insufficient to irrigate the command area by the surface method.

Sprinkler irrigation in field crops

Sprinkler irrigation system is suitable for irrigating crops where the plant density is very high and where adoption of drip irrigation system may not be economical. Sprinkler irrigation is suitable for horticultural crops like vegetables and seed spices. Conventionally, sprinkler irrigation has been widely in use for irrigating cereals, pulses, oil seeds and other field crops. The trials conducted in different parts of the country reveal water saving due to sprinkler system to the tune of 16 to 70% over that of the traditional method with yield increase from 3 to 57% in different crops.

General rules for sprinkler system design

- Water supply source should be located at the centre of the farm.
- Main line should be placed on the slope.
- Lateral should be placed along the contours or downhill slope to minimize pressure variation in the pipelines.
- The pressure variation in the lateral can be up to 20% of the design sprinkler pressure. With uniform sprinkler nozzles, the variation in the sprinkler discharge will then be limited to 10% of the design discharge.
- When the system is designed for a part of farm, consideration should be given to the possibility of expanding the system to cover the entire area.

A scene of sprinkler set

- Layout should be modified to apply different rates and amounts of water where soils are greatly different.
- Layout should facilitate and minimize lateral movement during the season.
- The design should be such that the operation of the system will result in minimum interference with other farm operations.
- For irregular fields the design should minimize the variations in the number of sprinklers that would be operating at any given time.
- Booster pump should be considered where a small portion of the field requires high pressure at the pump.
- Proper safety devices for the power unit and pumping plant must be provided which will infuse an automatic shutdown of the pump in case of overheating of motor or engine or failure of water supply in the design.
- Lateral lines should be located at right angles to the prevailing wind direction wherever possible.

Advantages of sprinkler irrigation

- Saving of water varies from 25 to 50% for different crops.
- When water is sprayed like rain, there is little or no puddling effect on soil.
- There will be no soil erosion problem, no compaction of soil during irrigation and no land leveling required.
- Areas located at an elevation higher than the source can be irrigated.
- Suitable for irrigating crops where the plant population per unit area is very high. It is most suitable for oil seeds, cereals and vegetable crops.
- Fertilizer can also be applied through the sprinkler system, which saves labour.
- It may well be less expensive than the surface method, since land leveling and construction of channels are not needed.

Limitations of sprinkler irrigation

- High wind distorts sprinkler patterns and causes uneven distribution of water.
- Ripening fruits must be protected from the spray.
- A stable water supply is needed for the most economical use of the equipment.
- The water must be clean and free of sand debris and large amounts of dissolved salts.
- The sprinkler method usually requires the highest initial investment.
- Power requirement is usually high.
- High water pressure required in sprinkler (>2.5 kg / cm^2)
- More water is lost by evaporation during sprinkling under high temperature.
- Fine textured soils that have a slow infiltration rate cannot be irrigated efficiently in hot windy area.
- Difficulty in irrigation during wind.

Land Leveling Techniques

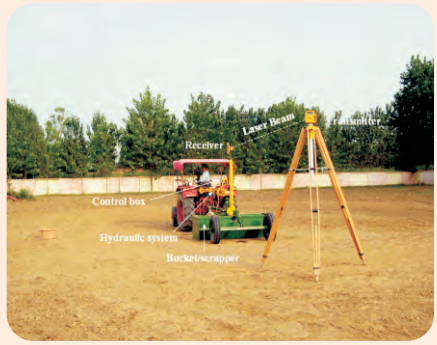
(i) Manual leveling

The traditional method of manual land leveling includes surveying the field, staking and designing the field, calculating of cuts and fills and then using a scraper and a land planer to even the land. Despite all these labour-intensive efforts, the desired accuracy and a high level of smoothness of land surface is not achieved.

(ii) Laser land leveling

Farmers traditionally have been practicing land leveling in their fields by using animal drawn or tractor drawn levelers. These levelers are simple implements consisting of a blade and a small bucket for shifting the soil from higher spot to the low-lying positions. Traditionally leveled or unleveled lands lead to water logging conditions at

low lying areas and less soil moisture in higher levels. Significant amount (10-25%) of irrigation water is lost during application at the farm due to poor management and uneven fields. Excessive irrigation at low lying areas leaches soluble nutrients from the crop root zone and makes the soil less productive. On the other hand, germination and crop stand are affected adversely by low soil moisture at higher levels.



Laser leveler machine

Precision land leveling is expected to enhance water use efficiency and consequently harness higher water productivity. Precision land leveling helps in controlling the emergence of salt affected patches, increasing cropping intensity and crop productivity in cultivable land area by 3-5 per cent, improving the crop establishment, reducing the weed intensity and saving the irrigation water.

Laser leveling is the process of smoothening the land surface ± 2 cm from its average elevation by using laser equipped drag buckets to achieve precision in land leveling. Precision land leveling involves altering the fields in such a way as to create a constant slope of 0 to 0.2%. This practice makes use of large horsepower tractors and soil movers that are equipped with global positioning systems (GPS) and/or laser-guided instrumentation so that the soil can be moved either by cutting or filling to create the desired slope/level.


Laser land leveling

Components of laser land leveling system

The laser leveler involves the use of laser (transmitter) that emits a rapidly rotating beam parallel to the required field plane, which is picked up by a sensor (receiving unit) fitted to a tractor towards the scraper unit. The signal received is converted into cut and fill level adjustment and the corresponding changes in the scraper level are carried out automatically by a hydraulic control system. The scraper guidance is fully automatic; the elements of operator error are removed allowing consistently accurate land leveling. The setup consists of two units. The transmitter is a laser, which is mounted on a high platform. It rapidly rotates, sends the laser light in a circle like a lighthouse does, except that the light is a laser, so it remains in a very narrow beam.

A laser controlled land leveling system consists of five major components:

(i) Drag bucket

(ii) Laser transmitter

(iii) Laser receiver

(iv) Control box, and

(v) Hydraulic system

Benefits of precision land leveling

Laser controlled precision land leveling helps in-

- Improving crop establishment.
- Improving uniformity of crop maturity.
- Increasing approximately 3 to 5% of cultivable land area.
- Increasing water-application efficiency potential up to 50%.
- Increasing cropping intensity up to 40%.
- Increasing yield of crops (wheat 15%, sugarcane 42%, rice 61% and cotton 66%).
- Controlling the emergence of salt affected patches in the soil.

- Saving in irrigation water by approximately 35-45%.
- Reducing weed problems and improving weed control efficiency.

Limitations of laser leveling

- High cost of the equipment/laser instrument.
- Need for skilled operator to set/adjust laser settings and operate the tractor.
- Less suitable for uneven and undulated fields.

Aqua-Fertilization Technology (Aqua-Ferti-Seed Drill) for dry lands

- Aqua-fertilization sowing facilitates the artificial drilling of water in the vicinity of seed zone and helps in quick availability of essential nutrients.
- Aqua-sowing technology improves the crop stand of *rabi* dry land crops like wheat, lentil, mustard, etc.
- The technology improves the nutrient and water use efficiency of dry land crops.
- The technology also improves the productivity and net return of dry land crops.

Other Water Saving Techniques

- First irrigation at crown root initiation (CRI) stage in dwarf wheat, irrigation at pre-flowering stage in peas, chickpea and lentil; and branching and seed filling in fennel were found critical.
- Technologies for improving water use efficiency by modified tillage and sowing methods such as alternate furrow irrigation, furrow irrigated raised bed system, system of rice intensification, sprinkler and drip methods were worked out in different crops, which led to improved water-use efficiency.

Agro-techniques for water economization in wheat

- Wheat sowing by broadcast (50%) + line sowing (50%) and criss-cross methods augmented the yield and water use efficiency.
- Irrigation at crown root initiation(CRI) stage increased the yield and water use efficiency.
- Under limited water supply, wheat responded better to irrigation at CRI + boot + milk stages.

Agro-techniques for water economization in cauliflower

- An application of 60 kg N + 30 kg P_2O_5 + 12.0 t FYM/ha raised the curd yield along with water use efficiency.
- Planting and irrigation in furrows proved to be the best for cauliflower as they produced significantly the highest marketable yield of cauliflower curd, the highest water use efficiency, net return and B:C ratio.

Agro-techniques for water economization in potato

- Planting on ridges, and furrow irrigation were superior for potato tuber yield.
- Among potato based intercropping systems, potato + radish intercropping was the best when irrigation was applied in each furrow. Water use efficiency and net return were the highest in this method.

Agro-techniques for water economization in green gram

- Summer green gram is the most beneficial crop for achieving water economy by irrigating it thrice at branching, pre-flowering and pod-filling stages with furrow planting and irrigation method and VAM inoculation.
- Water economization in summer green gram could be achieved by its better performance when it was irrigated at various stages and sown in furrow irrigated raised bed system(FIRBS).

Agro-techniques for water economization in *Brassica* sp.

- Among *Brassica* sp., *Brassica juncea* responded best to one irrigation at flowering and recommended dose of fertilizer (80 kg N + 40 kg P_2O_5/ha).

Agricultural Physics Based Technologies

Soil compaction technology

Productivity of coarse-textured loamy sand soil is relatively low due to its excessive permeability, which causes deep percolation of water and nutrients beyond root zone, discouraging the farmers to use high level of these costly inputs.

A 'compaction technology' which brings the soil particles close to each other, was developed to reduce percolation losses of water and nutrients, evaporation losses of water, and irrigation water requirement of crops grown on these soils.

Bullock driven roller

It involves having 4 to 20 rounds of a tractor or bullock drawn roller (depending upon its weight), in the field at an optimum moisture or within 24 hours of irrigation/heavy rainfall. The compacted sandy or loamy sand soils have 30-75 per cent reduced infiltration rate, require 40 per cent less water in each irrigation, retain moisture for a longer period, improve germination, provide anchorage to plant roots, reduce the attack of white ant and white grub and increase the uptake of nutrients, thereby enhancing the production potential of these soils by 15%. Compaction also resulted in higher moisture retention by soil, thereby reducing the leaching losses to a large extent.

Chisel technology

Productivity of the soils having high mechanical impedance layers at shallow depth is poor due to its adverse effect on the plant growth, especially rainfed crops. These soils impede the root penetration to fertile sub-soil region, the store-house of moisture nutrients. The high mechanical impedance layers (hardpan) at shallow depths are developed either naturally or due to the tillage operations carried out in sandy loam, silt loam and silty clay loam soils.

The chisel technology was developed to reduce the sub-surface mechanical impedance of these soils. It involves chiseling of the dry soil to 30-45 cm depth at 50-120 cm intervals depending upon the location of impedance layers and row to row spacing of the plants. In this technology, a chisel, generally mounted in place of a plough, is used to break sub-surface soil layer.

The chiseling encourages deep root growth, and increases infiltration of rain and irrigation water, thereby increasing the water storage in the sub-surface soil and improving aeration in the root zone of temporarily water logged soil.

Tractor drawn chiseller

Bed planting technology

Research trials on sandy loam soil at IARI, New Delhi showed that 37.5 cm wide beds alternating with 30 cm wide furrows were most suited for growing three rows of wheat in *rabi*, one row of maize and two rows of soybean in *kharif*. As compared to conventional planting, growing of these crops on beds not only save fuel and labor but also water, seed, fertilizer and pesticides, besides maintaining the same or higher crop productivity. It

also improves soil physical environment as evident from the reduction in bulk density and penetration resistance, and the increase in infiltration rate and root growth.

Rear view of the Bed planter

Advantages

- Bed preparation along with mechanized seeding of row crops like maize, wheat, soybean, cotton, etc., in one operation, thus saves fuel cost and manpower.
- Reduces seed rate.
- Reduces fertilizer and irrigation water application.
- Provides drainage under rainfed conditions where water logging can occur.
- Reduces compaction because of controlled traffic pattern.
- Reduces crop lodging.
- Easy field access for hand weeding during later crop stage and other inter-cultivation practices.


Wheat crop under bed planting system

De-branching technology for mustard

De-branching of mustard plant facilitates higher radiation penetration and thus reduces white rust disease and increases yield. Water use efficiency in the de-branched plots was higher as compared to control plots.


De-branched plot of mustard

Weather based agro-advisories

Weather-based Agro-advisory Unit, located at the Insitute, issues weekly agro-advisories for the benefit of the farming community. Need based crop management information (along with past week weather data and forecast for the next four days) is given with the help of the print and electronic media. The weekly agro-met advisory bulletins are provided to the farmers on real time basis. These weather forecast agro-advisories have been helping farmers in taking tactical farm decisions related to crop management. A web page has been developed and being maintained at IARI website (www.iari.res.in/dainikmausam aur krishak sewa). In this web page weather related information is available and is printed frequently in newspapers (*Dainik Jagraon and AAJ Samachar*).


Weather based agromet advisories in service of the farming community

7

Plant Protection Technology

Management of Insect-Pests

The management of insect-pests assumes greater significance because of the colossal loss of produce and income due to their infestation. This calls for effective management of insect-pests through adoption of integrated pest management practices. The symptoms of damage and the management practices of major insect pests of the selected crops are described below:

Insect-pests of field crops

Insect-pests	Management

Rice

Stem borer: Three species of stem borer (yellow stem borer, pink stem borer and white stem borer) damage rice crop. The larvae of this insect enter the central whorl of leaf and cut it, that subsequently dries and turns brownish. This symptom is called 'dead heart'. When plants are attacked at panicle initiation stage, larvae feeding results in drying of panicles, which are termed as 'white ears'. These 'dead hearts' or 'white ears' can be easily pulled from the plant. These insects attack the plants from tillering stage to maturity but peak infestation is during September to October.

- Economic threshold level (ETL): 5% 'dead hearts' or 2% 'white ears' or 1 egg mass/m^2 or 1 moth/m^2.
- Avoid excessive use of nitrogen fertilizers.
- Cut tips of seedlings before transplanting.
- After 30 days of transplanting, release *Trichogramma japonicum* @1,00,000-1,50,000/ha/week for 2-6 weeks.

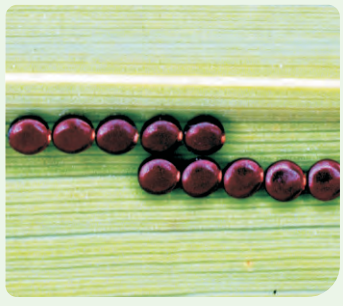
Stem borer

- At the time of harvesting, cut the stems near ground level and destroy the stubbles of crop.
- Depending upon need, apply granular insecticides like carbofuran 3G @ 25 kg/ha or cartap hydrochloride 4G @ 25 kg/ha or spray chlorpyriphos 20 EC or quinalphos 25 EC or endosulfan 35 EC @ 2 ml/l of water or cartap hydrochloride 50 SP @ 1ml/l of water.
- Grow resistant varieties like Ratna, Sasyasree, Vikas etc.

Insect-pests	Management
Plant hopper: Two types of plant hopper-brown plant hopper (BPH) and white backed plant hopper (WBPH) damage rice crop. Nymphs and adults suck sap from base of plants, which soon turn brownish due to drying. In case of severe infestation, circular patches of dried crop are seen which are termed as 'hopper burn'. Maximum infestation of this pest is observed during the months of September and October.	• ETL: 10 hoppers/hill. • Use nitrogen fertilizer judiciously. • Alternate wetting and drying of field proves effective. • Conserve natural enemies like spiders, mirid bugs and coccinnelids. • Give need based application of insecticides like carbofuran 3G @ 25kg/ha or fipronil 0.3G @ 20 kg/ha or spray imidacloprid 17.8 SL@ 1 ml/3l water, chlorpyriphos 20 EC @ 2 ml/l water, carbaryl 50 WP 2 g/l or thiomethoxam 25 WG 1 g/5l or BPMC 50 EC @ 1 ml/4l or buprofezin 25% EC @ 2 ml/3 l water.
	• For BPH, grow resistant varieties like Chaitaraga, Pratibha, and Chandana and for WBPH grow HKR 120 and HKP 126.
Leaf folder: The larva of leaf folder fastens the margins of leaf and feed on chlorophyll as a result of which transparent streaks are formed and later on the leaves get folded. Peak infestation months may be from mid of August to end of September.	• ETL: 2 damaged leaves/hill· • Avoid excessive use of nitrogenous fertilizers. Release *Trichogramma chilonis* @ 1,00,000-1,50,000/ ha/week for 2-6 weeks after transplanting. • Conserve parasitoids like rove beetle. • Depending upon need, spray quinalphos 25 EC @ 2 ml/l or chlorpyriphos 20 EC @ 2.5 ml/l or flubendiamide 3.35 EC @ 10 ml/5 l or cartap hydrochloride 50 SP 1 ml/litre or Acephate 75 SP 1 gm/litre water.
***Gundhi* bug:** The insect produces characteristic foul smell in field. The adults and nymphs suck the milk from the developing grains during milking stage. Infestation is characterized by the presence of some empty or partly filled grains having black spot at the point of puncture.	• ETL : one bug per plant· • Practice synchronous planting in an area. • Remove weeds like *Echinochloa.* • Depending upon need, apply carbaryl 50 WP 2 gram/litre water quinalphos 25 EC @ 2ml/l or malathion 50 EC @ 2ml/l of water or carbaryl/malathion dust @ 25-30 kg/ha.

Brown plant hopper

Leaf folder



Gundhi bug eggs

Insect-pests	Management

Mustard

Aphids: Both the nymphs and adults suck cell sap from leaves, stems, inflorescence or the developing pods. Due to the very high population of the pest, the vitality of plants is greatly reduced. The leaves acquire a curly appearance, the flowers fail to form pods and the developing pods do not produce healthy seeds. The honeydew excreted by the aphids provides congenial conditions for the growth of sooty mould on the plant. In case of severe infestation, the crop yield may be reduced by even 80 per cent or more.

- Sow the crop between 15th and 25th October.
- Use resistant varieties.
- Manually removal of infested shoots at early stages.
- Spray contact or systemic insecticides when the ETL level of 15-20 aphids/10 cm long inflorescence shoot is reached.
- Foliar spray of oxydemeton methyl 25EC, dimethoate 30EC, endosulfan 35EC, malathion 50 EC @ 1 litre of insecticide mixed in 600 to 800 litres of water per hectare. The spraying should be done in the evening, so that beneficial insects like honey bees and other pollinators are not affected.

Mustard aphids

Painted bug: The painted bug appears at two stages of crop growth, i.e., seedling stage and mature/harvesting stage. Both nymphs and adults suck cell sap from the leaves and developing pods, which gradually wilt and dry up. Severe attack at seedling stage may even kill the plants. The nymphs and adult bugs also excrete a sort of resinous material, which spoils the pods.

- Clean cultivation and quick threshing of harvested crop helps in lowering the incidence of the pest. Apply first irrigation 3-4 weeks after sowing of the crop. Dust crop with endosulfan 4% dust @ 20-25 kg/ha. Spray malathion 50 EC @ 500 ml or endosulfan 35 EC @ 625 ml in 500 litres of water per hectare in case of severe infestation. If incidence is at the advance stage of crop, spray crop with malathion 50 EC @ 1 litre in 1000 litres of water per hectare. Harvest at the golden stage of the crop. Thresh crop as early as possible to avoid further losses and dispose off the plant material immediately.

Painted bug

Insect-pests	Management
Cabbage butterfly: This pest was considered minor but for the last 4-5 years it has become a serious pest not only of mustard but also of other cruciferous vegetables. The larval stage is the damaging stage. The caterpillars feed on the leaves, flower and pods of the plant. The late maturing varieties of mustard particularly that of *Brassica carinata* are severely affected by this pest.	• Timely sowing of the crop should be done. • The egg masses and the first instar larvae should be collected and destroyed manually. • Spray the crop with malathion 50 EC @ 1 litre in 600-800 litres of water per hectare in case of severe infestation.

Cabbage butterfly

Soybean

White fly: Infestation due to white fly starts right from seedling stage and continues till the crop remains green. Both greenish yellow nymphs and light creamy white adults suck the sap from the leaves which reduce the vitality of the plants thus causing stunted growth of the plants. They also secrete honey-dew which when deposited on the leaves results in a sooty mould on the leaves, thus hampering photosynthesis. They also transmit yellow mosaic virus disease (YMV), a serious disease in the plains of northern India, resulting in yellow patches on the leaves. Heavy attack of the insect causes up to 80% grain yield loss.	• Seed treatment with thiamethoxam 70 WS @ 3 g / kg seed + need based spray of thiamethoxam 25 WG @ 100 g/ha.

White flies

Stem fly: Stem fly is a very serious pest throughout India. It remains active from sowing (June-July) to harvesting (October). Damage due to this pest starts right from germination and continues throughout the plant growth; the early stage of crop growth (up to 7-10 days after germination) is most vulnerable. Adults lay eggs either on cotyledonous leaves or first trifoliate leaves. Only larvae cause damage by burrowing into the stem.	• Early sowing (last week of June) helps in reducing the incidence of stem fly. • Spraying with ethofenprox 10 EC @ 1.0 l/ha or thiamethoxam 25 WG @ 100 g/ha.

Stem fly

Insect-pests	Management

Cotton

The IPM practices for control of cotton pests are given below:

Mealy bug: White waxy insects are found clinged to different plant parts. Both nymphs and adults cause damage by sucking the plant cell sap due to which plant becomes stunted. Number and size of bolls are reduced which are usually deformed.

Jassids: Adult insect is 3-4 mm in size and greenish yellow in colour walks diagonally. Both nymphs and adults cause damage by sucking the sap from lower surface of leaves at vegetative stage of the crop. Due to jassid infestation, leaves curl, turn red in colour and fall down on the earth after drying.

White fly: Small white colour insect of 1-1.5 mm size. This insect attack mainly before flowering and transmit leaf curl viral disease in cotton plants. Both nymphs and adults cause damage by sucking the cell sap thereby reducing the vitality of the plant. Sooty mould hinder photosynthetic activity of leaves. In boll opening stage blackening of lint can be seen.

Aphids: Small 2-3 mm soft bodied yellowish brown insects. Nymphs and adults of aphid cause damage by sucking sap from leaves and tender growing points which results in crinkling curling of upper parts of plant.

- Cultivate recommended resistant varieties.
- Timely sowing of crop in the larger area and use only recommended dose of nitrogenous fertilizers.
- Deep summer ploughing will kill hibernating insects.
- Treat the seed with imidacloprid @ 7.5 g/kg of seed in plastic tub.
- Conserve parasites like *Chrysoperla* and lady bird beetle, syrphid flies, etc. by intercropping.
- Keep the crop weed free at least for 8-9 weeks in the begining.
- In the beginning, red bugs can be collected and destroyed.
- Harvest the bolls at appropriate time to reduce the damage by bugs.
- To control jassids, use imidacloprid 17.8 SL @ 250 ml/ha or acetamiprid (Pride) @ 10 g/l water or methyl demeton 25 EC @ 500- 750 ml /ha or dimethoate 30 EC @ 500-750 ml /ha.
- To monitor white fly, use yellow sticky trap.
- White fly can be managed by using methyl demeton 25 EC @ 625 ml /ha or triazphos 40 EC 1-1.5 l/ha, thiomethaxam 70 WG 0.6 ml/l of water.
- For controlling aphid, use dimethoate 30 EC or methyl demeton 25 EC @ 1.0 l/ha or Imidacloprid 17.8 SL @ 250 ml /ha.

Mealy bug

Jassid

Aphids

Insect-pests	Management
Red cotton bug: Bugs are of red colour of 1.5- 2 cm size with white bands on the abdomen. Insects appear when crop is 50-70 days old. Both nymphs and adults cause damage by sucking the sap from leaves and green bolls. On infected bolls, yellow spots and on lint, red spots appear. Lint quality deteriorates during processing (delinting) due to crushing of bugs with lint. The oil content of seeds is also affected.	• To control red cotton bug, use dimethoate 30 EC or methyl demeton 25 EC @ 1.0 l/ha. • Alternate host plants like *Parthenium* sp. should be removed.
Dusky cotton bug: Adults are 4-5 mm long, dusky brown with dirty white transparent wings. Nymphs are smaller and wingless. Both nymphs and adults suck the sap from immature seeds, which may not ripen and remain light weight. Adults found in cotton get crushed during ginning thus staining the lint and lowering its market value.	• To control dusky cotton bug, use dimethoate 30 EC or methyl demeton 25 EC @ 1.0 l/ha. • Alternate host plants like *Parthenium* sp. should be removed.

Red cotton bug

Dusky cotton bug

Management of boll worm complex

Pink boll worm: Adults are small brown moths with black spotted forewings and fringed hind wings and the larvae are pink which bore into the bolls. Infected flowers are spun together by the larval silk and they do not open fully. Larvae of last generation hibernate in seeds and emerge as adults in next season.	• Deep summer ploughing to expose hibernating larvae and pupae of bollworms and defoliators. • Acid delinting treatment before sowing @ 1 litre commercial sulphuric acid for 10 kg seed in plastic containers and wash the seed thoroughly with water. • ETL: 8 adults per trip for 3 continuous days.
American boll worm: The adult moth is stout yellowish brown with dark speck on the forewings. The larvae feed on the leaves initially and then bore into the squares /bolls and seed with its head thrust in the boll leaving the rest of the body outside. A single larvae can damage several bolls.	• Clean cultivation and destruction of crop residues after the last picking. • Early, uniform and synchronous sowing of a promising variety in a given area. • Grow Setaria in between every 9 and 10 rows of cotton. • ETL: 1 egg/larva/plant or 5-10% affected bolls.

Pink boll worm

American boll worm

Insect-pests	Management

Spotted boll worm: The fore wings are green with a wedge shape white band. The larvae is about 20 mm long and brownish in colour with white streaks dorsally. The caterpillars first bore into the tender shoot and later into the buds, flowers and bolls. The infected bolls open prematurely and produce poor lint resulting in lower market value.

Tobacco caterpillar: The adult moth is stout with brownish forewings and whitish hindwings. The first instar larvae feed gregariously by scrapping the chlorophyll of leaf lamina. Later, they become solitary and infest squares, flowers and young bolls and cause considerable loss.

ETL: 1 egg mass or teasle clam egeal leave/ 10 plants.

Cotton leaf roller: Adult wings are yellowish white with black brown spots on head and thorax and series of dark brown wavy lines. On emergence the larvae briefly feed on the surface of the leaves and roll the leaf margins towards the midrib and feed on the leaf tissue from inside. During the severe infestation the plants may be completely defoliated.

ETL: 1 larva or 3 affected bolls 1 plant.

- Place/erect bird perches to enhance the activity of insectivorous birds.
- Treat the seed with imidacloprid @ 7.5 g/kg seed.
- Utilise pheromone lures for specific species of boll worms. Fix pheromone trap in the field at 21 days after germination for all the three species of boll worms @ 10 traps per hectare to monitor the pest population density. Keep the height of the pheromone traps 30 cm above the crop canopy and change the lure after every 20 days.
- Erect light trap @ 1 /ha.
- Spray neem seed kernel suspension (NSKS) 5% at 45 and 55 days of crop age.
- Release egg parasitoid *Trichogramma Chilonis* @ 1,50,000 /ha twice at weekly interval starting from 35-40 days of crop age.
- Spray HaNPV @ 250 LE/ha (repeat after 15 days) when young larvae of American bollworms are located in the field. It could be alternated with commercial Bt formulations @ 1.5 kg/ha.

Bt cotton management

- Use recommended variety of *Bt* cotton hybrids specific for different zones.
- The sowing of 5 rows of non *Bt* cotton or 20% of non *Bt* cotton, which ever is higher is mandatory for growing *Bt* hybrids.
- *Bt* crop needs management of sucking pests only as it can take care of boll worms itself.

Spotted bollworm

Tobacco caterpillar

Cotton leaf roller

Insect-pests of vegetables

Insect-pests	Management

Brinjal

Leaf hopper: Both adult and nymph suck the sap. Plants loose their vitality and affected leaves turn yellow.

Stem and fruit borer: Caterpillars of fruit borer feed inside the tender shoots before flowering and cause wilting of the affected shoots. Grown up caterpillars bore into the fruits.

Hadda beetle: Adults and grubs damage by feeding and scratching of leaves. Attacked leaves turn brown and fall early.

- Grow cluster bean as an inter-crop to suppress the insect-pest population.
- Clip and destroy borer damaged shoots.
- Install pheromone traps @ 5/ha for monitoring of borers.
- Collect all stages of Hadda beettle and destroy them.
- Release *Trichogramma brasiliensis* @ 1,50,000 lakh/ha for shoot and fruit borer.
- Spray thiamethoxam (2 g/l) or deltamethrin (1/ml water) for sucking pests.
- Undertake 2-3 need based spray either of cypermethrin (4 ml/10 l) or spinosad (2 ml/10l) at 10-15 days interval against fruit borer alternately.
- Avoid repeated use of same insecticides.

Fruit borer

Stem & fruit borers

Bhindi or Okra

White fly: Both adult and nymph feed on leaves by sucking cell sap. They also transmit yellow vein mosaic virus (YVMV).

Leaf hopper: Both nymph and adult suck the sap. Plants loose their vitality and the affected leaves turn yellow and curl upward.

- Treat the seed with imidacloprid (4 g/kg).
- After 35 days of germination, undertake need-based one spray of either acetamiprid (2 g/10 l) or imidacloprid (2 ml/ 10 l) for sucking pests and 1-2 sprays of either spinosad (3 ml/ 10 l) against fruit borer in rotation at 10 days interval.
- Install pheromone traps @ 5/ha for monitoring of fruit borer.

White flies

Leaf hopper

Insect-pests	Management	
Aphids: Both nymph and adult suck the sap from the tender leaves. **Fruit borer:** The larvae of fruit borer bore into the terminal portion of shoots in young plants and also damage flowers and fruits. Damaged shoot wither and wilt. Bored fruits get distorted.	• Release egg parasitoid *Trichogramma chilonis* @ 1,00,000-1,50,000/ha. • Grow baby corn as an inter-crop to enhance the activity of natural enemies like ladybird beetle and spiders. Clip and destroy borer damaged shoots. • Remove and burn virus affected plants.	 Fruit borer

Cauliflower/Cabbage

Diamond back moth (DBM): The first instar larvae mine inside the epidermis of leaves and later instars feed externally on the leaves.	• Use neem seed kernel extract (NSKE) 5% and other available neem formulations to minimize insect pest population at vegetative stage of the crop. • Collect and destroy the eggs of cabbage butterfly.	 Diamond back moth
Cabbage butterfly: The young caterpillars scrap the leaf surface, whereas the grown ups eat the leaves from the margin inwards sparing the main veins; often the entire plants are eaten up.	• Spray *Bt* (1g/l) or cartap (1g/l) for managing DBM population. • Use parasite *Cotesiaeoth nymphs* and adults @ 1000 adults/ha for control of DBM. • Intercropping of either sunflower or *berseem* or lucerne increases the activity of predators.	 Cabbage butterfly
Tobacco caterpillar: The caterpillars damage seedlings and plants by feeding on leaves during night.	• Spray thiamethoxam (2 g/10 l) or deltamethrin (1ml/l) against aphids. • Spray of Sl NPV (250 LE/ha) at flowering stage for control of tobacco caterpillar. • Do not repeat the same pesticide consecutively.	 Tobacco caterpillar

Insect-pests	Management	
Cabbage aphid: Both nymphs and adults suck the sap from leaves and tender stems. Vitality of plants is reduced.	• Undertake need-based spray of either spinosad (3 ml/10 l) or beta cyfluthrin (5 ml/10 l). • Repeat spray at 10-15 days intervals, if necessary.	 Cabbage aphids

Tomato

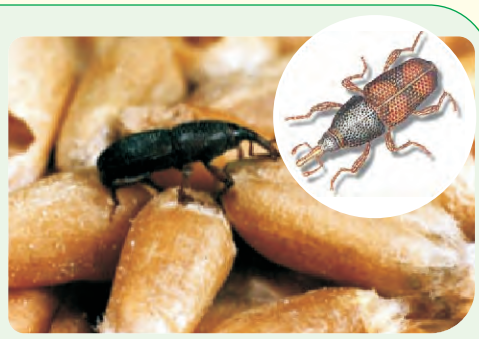
Fruit borer: First instar larvae of fruit borer scrap and feed on tender foliage while advanced stage larvae bore circular holes and thrust part of their body inside the fruit and eat the content.	• Apply neem cake @ 250 kg/ha 20 days after planting to reduce fruit borer & leaf miner population. • Spray thiamethoxam (2 g/10 l) or imidacloprid (2ml/10l) or NSKE 5% against sucking pests. • Release *Trichogramma pretiosum* @1.5 lakh/ha at flowering stage for fruit borer management. • Install specific pheromone traps @ 5/ha to monitor fruit borer. • Grow marigold as intercrop one row after every 15 rows of tomato for management of fruit borer.	 Tomato fruit borer
White fly: Both adult and nymph feed on leaves by sucking cell sap. They transmit viral disease.	• At flowering and fruit stages, undertake 1-2 sprays of methyl demeton (2 ml/l) or spinosad (2-3 ml/10 l) fenitrothion (2 ml/l) or deltamethrin (1 ml/l) against fruit borer in rotation at 10-15 days interval. • Spray Ha NPV @ 250 LE/ha.	 White flies

Insect-pest of fruit plants

Fruit fly: Fruit flies lay eggs in the holes in the outer covers of various fruits and cucurbitaceous vegetables by which fruits are damaged. These are seriously harmful at the maturity stage of fruits and all the stages of fruit bearing vegetables.	• Grow resistant varieties. • Collect and destroy fallen, damaged and over-ripe fruits on community basis at every 5 days interval. • Trapping of male fruit flies is done with the help of lure combined with an insecticide to reduce the male population.The male attractant methyl eugenol is use for the fruit flies infesting mango, guava, sapota, and bread fruit.	 Fruit fly infested guava

Storage pests

Insect-pests	:	Damage
Rice weevil *(Sitophilus oryzae)*	:	Rice weevil is a serious pest of paddy, wheat, barley, maize, sorghum and other cereals, which prefer temperate and humid climate, both larvae and adults cause damage. Young tiny grub bores into grain and starts feeding on the content of the grains. Infestation can be identified with emergence holes on the grains. Adults emerge from these holes.
Lesser grain borer *(Rhyzopertha dominica)*	:	Lesser grain borer is a major pest of wheat, barley, maize, *jowar,* paddy, etc. Prefers warmer climate. Both adults and larvae cause damage. Grub eats out starchy material of the grain. Profuse powdery substance is the characteristic of its damage. Heavily attacked grains become hollow and only their shells remain. Emergence holes of adults are visible on the grains.
Khapra beetle *(Trogoderma granarium)*	:	Khapra beetle is a major insect pest of wheat, *jowar*, *bajra*, maize, sorghum, etc. Adult is harmless and larva causes damage. Female beetle is bigger than male. Infestation due to this insect is usually at the superficial layer of the grain. Under abnormal conditions, larvae can survive without food for few years. Beetles convert the whole grain into frass. Infestation is identified by the presence of exuviae, frass and adults.
Red flour beetle *(Tribolium castaneum)*	:	Red flour beetle feeds on flour, *maida, suji*, starchy material and processed food. It mainly feeds on broken grains or grains attacked by other insects. Both adults and grubs cause damage. Heavily infested flour emits pungent smell.
Angoumois grain moth *(Sitotroga cerealella)*	:	Angoumois grain moth mainly infests wheat, maize, rice, barley, *jowar,* etc. Initial infestation starts when the crop is in the field and the grains are in milky stage. Damage is caused by larvae,which bore into the grain and feed. Larvae feed inside the grain and fill it with excreta and webbing. At high moisture content, the damage is severe. Damage is identified by flying tiny yellowish brown adults, dull appearance of the grain covered by scales of adults and holes with wavy margin on the grains.



Rice weevil

Lesser grain borer

Khapra beetle

Red flour beetle

Almond moth *(Cadra cautella)* : Almond moth mainly infests wheat, dry fruits, barley, etc. Larvae feed on stored produce, eating germ point only. Larvae spin silk profusely and at maturity they form small silken tubes among the food particles. After 4-5 days adult comes out.

Rice moth *(Corcyra cephalonica)* : Rice moth is an external feeder. Young larvae feed on broken grains. Larvae make webbing on food grain and after 4-5 weeks pupate. Besides polluting the grain with silken cocoon, webbing together with food grain forms the large lumps of food materials.

Tobacco beetle (*Lasioderma serricorne)* : Tobacco beetle infests mainly spices, chocolate, cocoa, tobacco leaves, etc. The insect prefers warm environment. Female adults are slightly bigger than males, and make small galleries in host.

Pulse beetle (*Callosobruchus* sp.) : Pulse beetle is a serious pest of grain legume in storage. Infestation can come from field to storage. It attacks peas, bengal gram, pigeonpea, black gram, cow pea, horsegram, etc. Adults are non feeding. Pulse beetle infests the whole grain. Different species of pulse beetle are responsible for infestation of various leguminous seeds. Adults lay tiny white eggs on the grains. Newly hatched larva enters the seed and feeds inside it. Adults comes out of the grain after pushing a circular lid prepared by prepupal stage of the larva. Damaged material showed the presence of adult, holes and eggs on the grains.

Almond moth

Rice moth

Tobacco beetle

Pulse beetle

Control Measures

- Before storing, clean the produce and remove broken grains.
- Dry the grain properly before storing so that the moisture content is reduced to less than 9%.
- Use "solar absorbance bed" to dry the grain. This bed is made up of double layered (250 m) black polythene sheets. It is used for drying as well as disinfesting the produce.
- After cleaning and reducing the moisture content of the grain, store it in "improved storage structures", *viz.*, Pusa Bin, Pusa *Kothar*, Pusa Cubicle. Use improved bamboo baskets for storing small quantities of seeds.
- For storing pulses split whole grain in splits (Dal).
- Before storing, storage structures, bins, rooms, sacks, and receptacles should be cleaned and disinfested with malathion 50EC @ 150 mg a.i. /m^2 or deltamethrin 2.5WP @ 25 mg a.i./m^2.
- If insect infestation occurs, fumigate the produce with aluminium phosphide @ 3 tablets (3 g) per 1000 kg grains or 140 tablets (3 g each) per 100 cu. m. space.

Diseases of various crops and their management

Infestation of some diseases in crops is increased due to expansion of improved agricultural activities. Diseases of important crops, their symptoms and management practices are given below:

Cereal crops

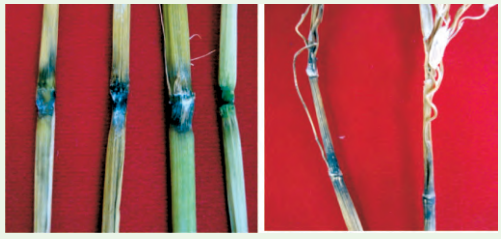
Diseases & their symptoms	Management

Rice

Blast: The fungus attacks the crop at all stages of crop growth from seedling to late tillering and ear heading stage. Symptoms appear on leaves, nodes, rachis, and glumes. On the leaves, the lesions appear as small bluish green flecks. The lesions soon enlarge under moist weather to form the characteristic spindle shaped spots with grey centre and dark brown margin (leaf blast); the infected nodes may die (nodal blast) and cause rotten neck/neck rot/panicle blast (neck blast). The pathogen causes yield losses upto 61 per cent depending upon the stages of infection.

Sheath blight: The fungus affects the crop from tillering to heading stage. Initial symptoms are noticed on leaf sheaths near water level. On the leaf sheath, oval or elliptical or irregular greenish grey spots are formed. As the spots enlarge, the centre becomes greyish white with an irregular blackish brown or purple brown border. Lesions on the upper parts of plants extend rapidly coalescing with each other to cover the entire tillers from the water line to the flag leaf. The presence of several large lesions on a leaf sheath usually causes death of the whole leaf, and in severe cases, all the leaves of a plant may be blighted in this way. The infection extends to the inner sheaths resulting in death of the entire plant. Older plants are highly susceptible. Plants heavily infected in the early heading and grain filling stages produce poorly filled grains, especially in the lower part of the panicle.

- Spray validamycin (Rizocin 3 l) or Sheathmar 25 ml/litre water or hexaconazole (contaf or sitara 5 EC 2 ml/litre water).
- Grow highly resistant to moderately resistant varieties CO47, IR 20, ADT36, ADT39, ASD 18, IR64 and avoid cultivation of highly susceptible varieties, viz., IR50 and TKM6 in disease favourable season.
- Remove and destory the weed hosts on the field bunds and channels.
- Treat the seeds with Captan or Thiram or Carbendazim or Tricyclazole at 2 g/kg or *Pseudomonas fluorescens* @ 10 g/kg of seed. Spray the nursery with Carbendazim 50 WP 25g or Edifenphos 50 EC 25 ml for 20 cent nursery.



Blast

Sheath blight

- Spray the main field with Edifenphos 500 ml or Carbendazim 250g or Tricyclazole (Beam)75 WP 500 g or Iprobenphos (IBP) 500 ml /ha.
- Use dhaincha, sunhemp as green manure and judicious use of area (N) when required.

Diseases & their symptoms	Management

False smut: A sporadic fungal disease. Caued by ustileginoidea virens fungus. The fungus transforms individual ovaries/grains into greenish spore balls of velvety appearance. Only a few spikelets in a panicle are affected.

Bacterial blight: The disease is usually noticed at the time of heading but it can occur earlier also. Seedlings in the nursery show circular, yellow spots in the margin that enlarge, and coalesce leading to drying of foliage. "Kresek" symptom is seen in seedlings, 1-2 weeks after transplanting. The bacterium enters through the cut wounds in the leaf tips, becomes systemic and causes death of entire seedling.

In grown up plants, water soaked, translucent lesions appear near the leaf margin. The lesions enlarge both in length and width with a wavy margin and turn straw yellow within a few days, covering the entire leaf. As the disease advances, the lesions cover the entire lamina which turns white or straw coloured. The affected grains have discoloured spots. If the cut end of leaf is dipped in water, it becomes turbid because of bacterial ooze.

- Apply organic amendments, viz., neem cake @ 150 kg/ha or FYM 12.5 t/ha.
- Avoid flow of irrigation water from infected fields to healthy fields. Deep plough in summer and burn the stubbles.
- Spray Carbendazim 250 g /ha. Soil application of *P. fluorescens* @ 2.5 kg/ha after 30 days of transplanting (The product should be mixed with 50 kg of FYM/sand and applied). Foliar spray 0.2% at boot leaf stage and 10 days later (1kg/ha).
- Maintain proper drainage in the field.
- Judicious use of NPK.
- Spray Cosaide 3000 (46.1 D F 46.1 copper oxychloride + 30% Copper metal) with 2.5-3.0 g/litre water. Spray Tilt (Propiconazole) 25% EC 2ml/litre in water.
- Burn the stubbles. Use optimum dose of fertilizers. Avoid clipping of tip of seedling at the time of transplanting. Avoid flooded conditions. Remove weed hosts.
- Grow resistant cultivars IR 20 and TKM 6.
- Spray streptomycin sulphate and tetracycline combination @ 300 g + copper oxychloride 1.25 kg/ha.

Bacterial blight

False smut

Diseases & their symptoms	Management

Wheat

Stem rust: Symptoms are produced on almost all aerial parts of the wheat plant but are most common on stem, leaf sheaths and upper and lower leaf surfaces. Uredial pustuls (or sori) are oval to spindle shaped and dark orange-red (rust) in color. They erupt through the epidermis of the host and are surrounded by tattered host tissue. The pustules are dusty in appearance due to the vast number of spores produced. Spores are readily released when touched.

Leaf rust: Caused by puccinia tritici and symptoms are oral, brown spots on leaves.

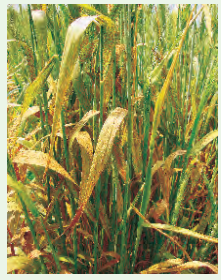
Teliospores are produced in the same pustule. The color of the pustule changed from rust color to black as teliospore production progresses. If a large number of pustules are produced, stems become weakened and lodge. Symptoms are very different on the woody host. Pycnia (spermagonia) produced on the upper leaf surface appear as raised orange spots. Small amounts of honeydew that attract insects are produced in this structure. Aecia, produced on the lower leaf surface, are yellow. They are bell-shaped and extend as far as 5 mm from the leaf surface.

Leaf blight: Reddish brown oval spots appear on young seedlings with bright yellow margin. In severe cases, several spots coalesce to cause drying of leaves. Fungus produces light brown coloured multicellular conidia singly or in chain.

Loose smut: It is very difficult to detect infected plants in the field until heading. At this time, infected heads emerge earlier than normal heads. The entire inflorescence is commonly affected and appears as a mass of olive-black spores, initially covered by a thin gray membrane. Once the membrane ruptures, the head appears powdery. Spores are dislodged, leaving only the rachis intact. In some cases, remnants of glumes and awns may be present on the exposed rachis. Smutted heads are shorter than healthy heads due to a reduction in the length of the rachis and

- Grow resistant cultivars like HI 500, HI 1530, HI 1531, HI 8498, HD 2781, HD 2773 HD 4672, HW 1085 HW-2004, DL-15302 etc.

Stem rust



Leaf rust

- In north-western plain regions grow stripe rust and leaf rust resistant varieties like DBW 17, HS 295, HS 490 PBW 550 etc.
- On appearance of spots spray 0.1 % propiconazole (Tilt 25 EC) on leaves once or twice.
- Soak the seeds in water for 4 h followed by 10 min. dip in hot water at 52°C. Spray the crop with Mancozeb or Zineb at 1.5 kg/ha.
- Treat the seeds with carboxin or carbendazim @ 2 g/kg.
- Grow loose smut resistant varieties like HS 277, BL 829, PBW 34.

Loose smut

Diseases & their symptoms	Management
peduncle. All or a portion of the heads on an infected plant may exhibit these symptoms. Other symptoms may be detected if the field is examined closely. While infected heads are shorter, the rest of the plant is slightly taller than healthy plants. Prior to heading, affected plants have dark green erect leaves. Chlorotic streaks may also be visible on the leaves.	• Soak the seed in water for four hours and after that place warm them in hot water (52 ^{o}C) for 10 minutes. • Grow disease resistant varieties like PBW 502, HS 365, PBW 34, HP 1731, HW 1014, Raj 1555, HD 4672 etc.
Karnal bunt: Symptoms are often difficult to distinguish in the field owing to the fact that incidence of infection on a given head is low. There may be some spreading of the glumes due to sorus production but it is not as extensive as that observed with common bunt. Symptoms are most readily detected on seed after harvest.	• Propiconazole @ 0.1% can be sprayed on leaves at boot leaf stage. • Spray thiram @ 3 g/kg.
The black sorus, containing dusty spores is evident on part or all of the seed, commonly occurring along the crease. Heavily infected seed is fragile and the pericarp ruptures easily. The foul, fishy odour associated with common bunt is also found with karnal bunt. The odour is caused by the production of trimethylamine by the fungus. Seed that is not extensively infected may germinate and produce healthy plants.	 Karnal bunt • Seed treatmment with 2.5 g/kg of carboxin (Vitavax 75WP). • Avoid water stagnation in filed and irrigation by sprinkler system.
Flag smut: The symptom can be seen on stem, culm and leaves from late seedling stage to maturity. The seedling infection leads to twisting and drooping of leaves followed by withering. Grey to greyish black sori occur on leaf blade and sheath. The sorus contains black powdery mass of spores.	• Treat the seeds with sulphur or carboxin @ 2 g/kg. • Grow resistant varieties like Pusa 44 and WG 377, VL 738, HS 277, HD 2189, HD 2687, HD 2733 etc.
Hill bunt: Symptom appears on tillers in which instead of grains, smut appears. Bad smell comes from infected tillers. • Spray the crop with moncozed or zineb 1.5 kg/ha. • At boot leaf stage spray 0.1% propiconazole on leaves. • Grow resistant varieties like PDW 237, Raj 1555, WH 896 etc. • Use disease free seed only.	 Hill bunt • Treat the seed with 2.5gm/kg carboxin or thiram or carbandazim.

Diseases & their symptoms	Management

Chickpea

Wilt: The disease occurs at two stages of crop growth-seedling stage and flowering stage. The chief symptoms in seedlings are yellowing and drying of leaves from base upward, drooping of petioles and rachis, withering of plants. In the case of adult plants, drooping of leaves is observed initially in the upper part of the plant, and soon observed in entire plant. Dark brown or black discoloration is noticed below and above collar region; advanced stages of the disease cause complete drying of the plant. Vascular browning is conspicuously seen as black streaks on the stem and root portion below the bark.

- Treat the seeds with Carbendazim or Thiram @ 2 g/kg or Carbendazim 1 g + Thiram 1 g/kg seeds.
- Treat the seeds with *Trichoderma viride* @ 4 g/kg or *Pseudonomas fluorescens* @ 10 g/kg of seed. Apply heavy doses of organic manure or green manure. Grow resistant cultures like ICCC 42, H82-2, ICC 12223, ICC 11322, ICC 12408, P 621 and DA1.

Dry and wet root and stem rot: In dry root rot, leaves become dry and brownish like straw and roots get dried. In wet root rot, plant becomes yellow and root softens. In stem rot, plants become yellow and the stem part touching root starts decaying.

- Same as wilt.

Wilt

Root rot

Blight (*Ascochyta* blight): All the above ground parts of the plant are attacked. On leaflets, the lesions are round or elongated, bearing irregularly depressed brown spots, and are surrounded by a brownish red margin. Similar spots may appear on the stem and pods. The spots on the stem and pods have pycnidia arranged in concentric circles as minute block dots. When the lesions girdle the stem, the portion above the point of attack rapidly dies. If the main stem is girdled at the collar region, the whole plant dies.

- Remove and destroy the infected plant debris in the field.
- Treat the seeds with Thiram @ 2 g/kg or Carbendazim 2 g or Thiram + Carbendazim (1:1) @ 2 g /kg.
- Exposure of seed at 40-50 °C reduces the survival of *A. rabiei* by about 40-70 per cent.
- Spray with Carbendazim @ 500 g/ha. Follow crop rotation with cereals.

Blight

Diseases & their symptoms	Management
Pea	
Powdery mildew: The initial symptoms are small, diffuse, off-coloured spots on the upper surface of the lowest and oldest leaves. These lesions appear later as white, powdery areas, and the severely infected foliage looks blue white. Tissue beneath these infected areas may turn purplish, after which small, black perithecia are formed in the mature lesions. Leaves, stems and pods may become infected, resulting in withering in foliage and occasionally in plant death. Severe pod infection may result in peas.	• Spray Karathane (1ml/l) or sulphonated chemicals, sulphex, allosol, dexsol (2 g/l) after appearance of disease and at an interval of 15 days, if necessary.
Rust: All the spore stages develop on every green part of the plant including the pods. The formation of the aecial stage is preceded by a slight yellowing which gradually turns brown. The yellow spots having aecia in round or elongated clusters are the earliest symptoms, which persist for long. The uredinia pustules develop on both surfaces of the leaves as well as on other parts. The teleutosori present a powdery, light brown appearance. The teleutosori occur in the same source as the uredinia and develop from the same mycelium. They are dark brown or almost black in colour.	• Spray Bavistin or Hexaconazole (1g/l) after the appearance of disease and at interval of 15 days, 2 or 3 times, if necessary.
Wilt: Head of the infected plant bends down. Vascular bundles become brown in colour, and slowly the whole plant becomes dry.	• Treat the seeds with Bavistin + Thiram (1:1) @ 2.5 g/kg seeds.
Lentil	
Wilt root and stem rot: Leaves become yellow and then fall down. Whole plant also dries. In root rot, root part darkens in colour and then they dry. In stem rot, the stem part touching the soil starts decaying.	• Treat the seeds with Bavistin + Thiram (1:1) @ 2.5 g/kg seeds or with Treat *Trichoderma* @ 4 g/kg seed.

Diseases & their symptoms	Management

Red gram

Wilt: The disease may appear from early stages of plant growth (4-6 week old plant) up to flowering and podding. The disease appears as gradual withering and drying of plants similar to that in drought. Yellowing of leaves and blackening of stem starting from collar to branches gradually result in drooping and premature drying of leaves, stems and branches, and finally death of the plant. Vascular tissues exhibit brown discoloration. Often, only one side of the stem and root system is affected resulting in partial wilting.

- Treat the seeds with *Trichoderma viride* @ 4 g/kg seeds.
- Avoid successive cultivation of red gram in the same field. Follow long crop rotation with tobacco. Adopt mixed cropping of sorghum in the field.
- Grow resistant varieties.

Blight (Stem blight): Initially purple to dark brown necrotic lesions girdle the basal portion of the stem and later may occur on aerial parts of the seedlings. Initially lesions are small and smooth, later enlarged and slightly depressed. Infected tissue becomes soft and the whole plant wilts. In grown up plants, infection is mostly confined to basal portions of the stem. The infected bark becomes brown and the tissue softens causing the plant to collapse. In leaf, localized yellowing starts from the tip and margin and gradually extends towards the mid-rib. The centre of the spots later turns brown and hard. The spots increase in size and cover a major portion of the lamina, leading to drying.

- Treat the seeds with Metalaxyl @ 6 g/kg. Spray Metalaxyl @ 500 g/ha or treat the seeds with Apron or Ridomil @ 2 g/kg seeds.
- Adjust sowing time so that crop growth should not coincide with heavy rainfall.

Green gram, Black gram and Beans

Yellow mosaic virus of Green gram: Initially mild scattered yellow spots appear on young leaves. Spots gradually increase in size and ultimately some leaves turn completely yellow. Infected leaves also show necrotic symptoms. Diseased plants are stunted; they mature late and produce very few flowers and pods. Pods of infected plants are reduced in size and turn yellow in colour.

- Crop must be sown timely.
- Only certified seeds should be used for sowing.
- If the seeds are not treated, then seed treatment should be done.
- In affected areas, only tolerant and resistant varieties should be used.
- Weed plants should be rouged out at their inception.
- Insect, fungal and nematode vectors should be controlled using suitable pesticides.
- Control white fly as it spreads the virus.
- Rogue out the diseased plants up to 40 days after sowing. Remove the weed hosts periodically. Increase the seed rate (25 kg/ha). Cultivate the crop during *rabi* season. Follow inter cropping by growing two rows of maize (60 cm x 30 cm) or sorghum (45 cm x 15 cm) for every 15 rows of green gram.

Diseases & their symptoms	Management
Yellow mosaic virus of Black gram: Initially small yellow patches or spots appear on green lamina. The young leaves are the first to show the symptoms. The yellow discoloration slowly increases and newly formed leaves may completely turn yellow. The infected plants normally mature later and bear very few flowers and pods. The pods are small and distorted. Early infection causes death of the plant before seed set.	• Rogue out the diseased plants up to 40 days after sowing. • Remove the weed hosts periodically. Increase the seed rate (25 kg/ha). • Grow resistant black gram varieties like VBN-1, PDU 10, IC 12/2 and PLU 322. Cultivate the crop during *rabi* season. • Follow mixed cropping by growing two rows of maize (60 x 30 cm) or sorghum (45 x 15 cm) or cumbu (45 x 15 cm) for every 15 rows of black gram or green gram.
Cercospora leaf spot of Green gram: This disease usually occurs in a severe form, causing heavy losses in yield. Spots produced are small, numerous in numbers with pale brown centre and reddish brown margin. Similar spots also occur on branches and pods. Under favourable environmental conditions, severe leaf spotting and defoliation occur at the time of flowering and pod formation.	• Cultivate resistant varieties. • Inter-crop *moong* with tall growing cereals and millets. • Follow clean cultivation. • Use disease free seed. • Maintain low crop population density and wide row planting. • The crude extracts of cassava, garlic, and ginger are applied for controlling the disease effectively
Cercospora leaf spot of Black gram: Small, circular spots develop on the leaves with grey centre and brown margin. Several spots coalesce to form brown irregular lesions. In severe cases, defoliation occurs. The brown lesions may be seen at petioles and stem in severe cases. Powdery growth of the fungus may be seen at the centre of the spots.	• Remove and burn infected plant debris. Spray Mancozeb @ 1 kg/ha or Carbendazim @ 250 g/ha.
Cercospora leaf spot of Beans: Light to dark grey or brown areas varying from specks to large blotches appear on seeds. The disease primarily affects foliage, but stems, pods and seeds may also be infected. Leaf lesions are circular or angular, at first brown, then light brown to ash grey with dark margins. The leaf spot may coalesce to form larger spots. When lesions are numerous, the leaves wither and drop prematurely. Lesions on pods are circular to elongate, slightly sunken and reddish brown.	• Use resistant varieties. • Use healthy or certified seeds. • Rotate soybean with cereals. • Completely remove plant residue by cleanly ploughing the field soon after harvest. • Destroy previous years infected stubble. • Treat the seed with Thiram + Carbendazim (2:1) @ 3 g/kg seeds.

Diseases & their symptoms	Management

Cauliflower and Cabbage

Black rot: The tissue at leaf margins becomes yellow; chlorosis progresses toward the leaf centre, creating a V-shaped area with the base of the "V" at the leaf midrib.

- Spray Streptocyclin (5 g) and Blitox (100 g) per 10 litre of water after transplantation and after an interval of 20 days as per requirement.

***Sclerotinia* rot:** Disease first appears as wet soft lesions on cauliflower curd and leaf scar on the stump region left behind due to defoliation of old leaves in cabbage head which enlarge into a watery rotten mass of tissues that is covered by white silvery appearance.

- Spray Bavistin (1 g /l) or Dithane M-45 (2 g/l) from the appearance of disease and @ 15 days interval based on necessity.

Sclerotinia rot

Black spot: Light brown spots appear on leaves. The infected leaves become yellow and fall down when mature.

- Treat the seed with Eglal, Eretan or Thiram @ 2.5 g/kg seeds or spray at 15 days interval as needed.

Downy mildew: Downy mildew infection begins as angular yellow spots on the upper leaf surface. Then they become brilliant-yellow. Eventually, the internal parts of these spots become brown with yellow margins. The underside of this infected leaf has fine, greyish fungal growth. Infected young shoots, fruits, and seeds have white coating of fungal spores.

- Spray Ridomil MZ-72 (3 g/l) after 30 days of sowing and at an interval of 15 days, if necessary.

Brinjal

***Phomopsis* blight:** In seedling infection, it causes damping off symptoms. When the leaves are infected, small circular spots appear which become grey to brown with irregular blackish margins, petiole and stem, causing blighting of affected portion of the plant. The infected fruits appear as minute, sunken, dull and dusky spots, which later merge to form rotten areas.

- Dip the plant roots for 20 minutes in water solution of Bavistin 50 WP (1/2 g/l) and spray 3 weeks after transplanting or as per requirement.

Phomopsis blight

Diseases & their symptoms	Management

Tomato

Damping off: The symptoms of disease occur in two phases, i.e., pre-emergence and post-emergence damping off. In the former, there is failure of seedling emergence from the soil either due to seed rots or death of young seedlings before their emergence from the soil, resulting in patchy appearance of seedlings stands in the nursery in the early stages of growth. In the case of post-emergence damping off, the disease outbreak is characterized by toppling over of infected seedlings at any time after their emergence from the soil. The infected tissue initially appears to be water soaked and soft, and subsequently, the stem at the infection points gets constricted resulting in toppling over and mortality of the seedlings.

- Spray Captan or Blitox (2.5 g/l), treat the seeds and seedlings with *Trichoderma harzianum* @ 4 g/ l.

Damping off

Leaf curl: Severe stunting of the plants with downward rolling and crinkling of the leaves. The newly formed leaves show chlorosis. The other curled leaves become leathery and brittle.

- Spray Confidor 200 LS (100 ml/500 l)/Malathion 50 EC or Rogor 30 EC; 3 weeks after transplanting and at 15 days interval, if necessary.

Leaf curl

Chillies

Anthracnose and fruit rot: Diseased areas on fruits develop as dark, round, sunken spots. Infected fruits drop off prematurely. Black, minute spots develop on the infected seed.

- Spray Captan or Blitox 50 (2 g/l) after the appearance of the disease.

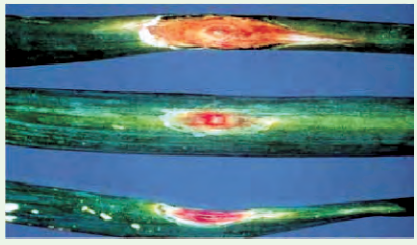
Diseases & their symptoms	Management
Mosaic and leaf curl: Infected plants exhibit mosaic, mottling, blistering and deformation of leaves. At times, small rings are also observed on the leaves. Mottling symptoms are also noticed on the infected fruits. Symptoms consist of abaxial and adaxial curling of the leaves accompanied by puckering and blistering of interveinal areas and thickening and swelling of the veins.	• Spray Confidor 200 SL (2 ml/l) 20 days after transplanting and at 15 days interval, if necessary.

Fruit rot

Leaf curl

Onion and Garlic

Purple blotch: Small white sunken spots develop on the leaves. These lesions enlarge and become zonate and under moist condition, turn purple. The lesions are very prominent on inflorescence stalks. Older leaves are more susceptible to the infection. Lesions may girdle the stem resulting in the breaking of stalk or leaf. The bulb tissue becomes papery.	• Spray Indofil M-45 or Blitox 50 (2 g/l) at 10 days interval, if necessary.



Purple blotch

Ginger

Rhizome and soft rot: The infection starts at the collar region of the pseudostems and progresses upwards as well as downwards. The collar region of the affected pseudostem becomes water soaked and the rotting spreads to the rhizome resulting in soft rot. At a later stage, root infection is also noticed. Foliar symptoms appear as light yellowing of the tips of lower leaves which gradually spreads to the leaf blades. In the early stages of the disease, the middle portion of the leaves remains green while the margins become yellow. The yellowing spreads to all leaves of the plant from the lower region upwards and is followed by drooping, withering and drying of pseudo stems.	• Spray Ridomil MZ-72 (3 g/l) after plant emergence and at 15 days interval, if necessary.

Diseases & their symptoms	Management
Potato	
Early blight: The disease starts appearing on potato crop just before tuber development. Symptoms develop on the lower most leaves. Infected leaves show brown spots which may be angular, oval or circular. The spots may or may not have concentric rings. The rings are more prominent in large blotchy spots and give them a target board effect. The disease can be distinguished from late blight by the absence of white cottony fungal growth. When a spot appears on the vein, a part of it gets necrosed.	• Spray Indofil M-45 (2 g/l) or Blitox 50 (2.5 g/l) after 30 days of sowing and at 10 days interval, if necessary. • Spray Indofil M-45 (2 g/l water) or Blitox 50 (2.5 g/l water) after 30 days of sowing and at 10 days interval, if necessary. • Grow resistant varieties.
Late blight: Late blight affects leaves, stems and tubers. It appears on the leaves as pale green, irregular spots. The spots in the beginning are more localized on the tips and margins of the leaves. In moist weather, the spots enlarge rapidly with central tissue turning necrotic and dark brown or black. Often, the spots have a purplish tinge. On the lower side of the leaves, a white mildew (cottony growth) ring forms around the dead areas. In dry weather, the water soaked areas dry up and turn brown.	• Spray Ridomil MZ-72 (2 g/l) after the appearance of disease and at 10 days interval, if necessary.
Leaf roll, leaf crinkle and mild mosaic: The symptoms are confined to top young leaves, which usually stand upright, roll and turn slightly pale. Infected plants have characteristic pale, stunted and upright appearance with rolling of lower leaves that turn yellow, brittle and are leathery in texture.	• Spray Confidor 200SL (100 ml/ 500 l) per hectare after 30 days of sowing, and second spray after 50 days interval, if necessary.

Bio-formulations of *Trichoderma* for commercialization

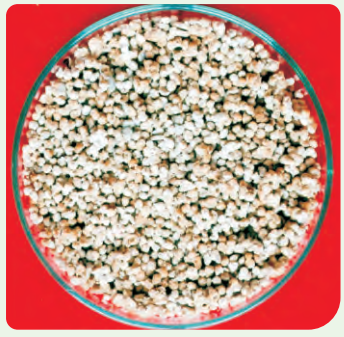
Two novel seed dressing **Pusa 5 SD** and soil application **Pusa Bio-pellet 10 G** bio-formulations have been developed from the potential isolate of *Trichoderma harzianum* (IARI P-4; MTCC No. 5371) for the management of soil and seed borne diseases of crop plants. The formulations showed longer shelf life (viability). Pusa 5SD is suitable for storage for 2 years and Pusa Bio-pellet 10G for 1.5 years at room temperature (25 -80^{O}C).

The formulations were effective against several soil and seed borne diseases of crop plants, namely, wilt of chickpea (*Fusarium oxysporum* f. sp. *ciceris*) and dry root rot (*Rhizoctonia bataticola*) and wet root rot/web blight (*Rhizoctonia solani*) of chickpea and mungbean. They increased seed emergence (30-86%) by providing protection to germinating seeds in the soil; as a growth promoter enhanced shoot (20-33%) and root (10-15%) lengths of treated plants and increased grain yield (46-88%) along with this highest yield (46-88%) under field conditions. Pusa 5 SD showed superiority over recommended fungicides for seed treatment [carbendazim (Bavistin^{TM}) + tetramethyl thiuram disulphide (Thiram^{TM}) and carboxin (Vitavax^{TM})] by increasing seed germination, enhancing plant vigour and grain yield and reducing disease incidence.

They are compatible with fungicides, namely, carboxin, tetramethyl thiuram disulphide and thiophanate methyl (Topsin M^{TM}) and *Rhizobium* sp., when applied as seed treatment under sick field conditions.

Pusa 5 SD + Pusa Bio-pellet 10 G + Carboxin

Bioformulation Pusa 5 SD



Pusa Bio-pellet 10G

Integrated disease management of mungbean Urdbean

A combination of seed treatment with thiamethoxam (Cruiser^{TM}) at 4 g kg^{-1} and carbendazim (Bavistin^{TM}) + tetramethyl thiuram disulphide (Thiram^{TM}) at 2.5 g kg^{-1} (1:1 ratio) followed by foliar applications of thiamethoxam (Actara^{TM}) 0.02% and carbendazim 0.05% at 21 and 35 days, after sowing produced the respectively, highest seedling establishment, shoot and root lengths, number of pods, plant biomass, and grain yield in mungbean (*Vigna radiata*) with the lowest intensity of cercospora leaf spots (*Cercospora canescens* and *Pseudocercospora cruenta*) and mungbean yellow mosaic (Mungbean yellow mosaic virus). Vector (whitefly) populations were also the lowest in this treatment during all stages of the crop. It was also best for 1000-seed weight and the number of *Rhizobium* root nodules per plant. This treatment was cost effective as it obtained the highest input:return ratio (1:5.3) in terms of rupees.

Integrated disease management in mungbean

Management of Nematodes

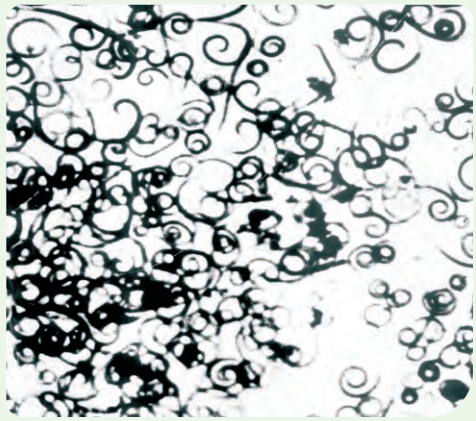
Nematodes are thread like micro-organisms. They have subterranean habitat and damage roots of various crops leading to the development of nutrition deficiency like symptoms. The symptoms generally include stunting and unthrifty growth, yellowing, and patchy growth. The nematode damage symptoms like swelling of roots are most prominent in vegetable crops. The important symptoms and their control measures for cereals, pulses, vegetables and citrus are summarized hereunder:

Plant Parasitic Nematodes

Rice-root nematode (*Hirschmanniella oryzae, H. mucronata*): Rice-root nematodes (*H. oryzae* and *H. mucronata*) feeds on young roots and cause water soaked lesions, yellowing or reddish brown discoloration of leaves and stunting of plants in patches, and reduction in number of tillers leading to extensive discoloration and rotting of root system, fewer and shorter panicles and spikes, poorly filled grains, and reduction in yield (10-15 %).

Control

- Rotation of non-host crops like wheat, linseed, potato, cauliflower, mustard, berseem, and chickpea in *rabi* or jute and groundnut in *kharif.*
- Carry out deep ploughings during peak summer.
- Treatment of nursery beds twice with Carbofuran @ 1 kg a.i./ha once at the time of sowing and again 1 week before transplanting.
- Application of Carbofuran @ 1 kg a.i./ha in two equal split doses, 7 days and 50 days after transplanting.
- Maintainance of sanitation.
- Removal of alternative hosts like *Echinochloa, Cyperus, Monochloria, Marsiliea,* etc.



Microscopic view of nematodes

Rice root-knot nematode (*Meloidogyne graminicola and Meloidogyne triticoryzae)*: Rice root-knot nematodes (*M. graminicola*) parasitize nurseries and upland transplanted paddy. They cause yellowing or bronze coloration from margins towards midrib, and stunting of foliage in patches, club or curved terminal galls on roots; reduction in tillers; fewer and smaller spikes with poorly filled grains; and reduced yield. Nematodes survive as eggs or second-stage juveniles in root pieces or soil; spread with infested soil, water and infected seedling. *Echinochloa*, wild rice, *Phalaris minor*, soybean, mung and tomato support the nematode. They can reduce the yield of rice by 40%.

Terminal curved gall roots

Control

- Soil solarization of area for nursery-beds for 3 weeks in summer.
- Nursery bed treatment with Carbofuran or Phorate @ 1 kg a.i./ha.
- Good puddling before transplanting.
- Crop rotation with jute and chickpea/ *Tagetes*/ *Crotolaria*/ cucurbits/ egg plant/ broad leaf weeds.
- Grow tolerant varieties like TKM 6, Dumal, Ch 47 and Hamsa.
- Seed soaking in Carbosulfan @ 0.1% for 1-2 h.
- Treatment with Carbofuran @ 1 kg a.i./ha in two equal split doses 15 and 45 days after sowing or transplanting.

Nematode infested rice field

Seed-gall nematode of wheat (*Anguina tritici*): Seed-gall nematode causes ear-cockle disease of wheat; young plants show swelling of stem near the base, twisting and crinkling of affected leaves, and premature tillering. Nematode enters the flower at heading stage and converts it into dark-brown galls instead of grains; affected ears become shorter with spreading glumes bearing very short or no awns. Nematode can survive for over 30 years inside the galls as dry quiescent second stage juveniles and spread through seeds contaminated with galls. It causes a yield loss upto 50%.

Seed-gall diseased grains

Control

- Infested seeds are cleaned to remove galls by sieving, winnowing or flotation in water; galls being lighter in weight can be removed easily and destroyed.
- Dip wheat seeds in 5% salt solution; floating galls can be removed and destroyed. Treated seed should be rinsed repeatedly in plain water and dried in shade before sowing.

Seed-gall diseased ears

Tundu disease or seed-gall nematode + bacteria complex (*A. tritici* + *Clavibacter michiganensis*): The nematode causes Tundu, i.e., yellow slimy ear-rot or tanan of wheat in cool humid weather. Symptoms on young plants are similar to those of ear-cockle disease. Ear-heads become sticky and covered with yellow slimy liquid, and do not produce seeds. Spikes are sterile and twisted, smeared with yellow bacteria ooze. It spreads with wheat seed contaminated with galls.

Control

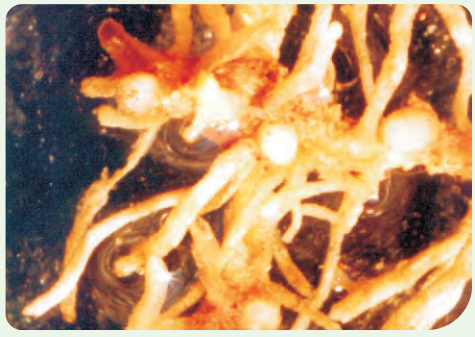
Same as for ear-cockle disease

Tundu diseased ears

Molya disease or Cereals cyst nematode (*Heterodera avenae*): *H. avenae* causes Molya disease of wheat and barley in north - western India. The disease appears as small patches of pale greenish-yellow plants, and spreads in area over the years. Reduction in tillers and flowering occurs early, and shorter ears with fewer spikelets are produced, which have poorly filled grains. Roots are shorter, stubby, profusely branched and appear dirty white. This can cause yield reduction up to 30%.

Control

- Deep summer ploughing 2-3 times at 10-15 days intervals during the months of May-June.
- Crop rotation with mustard, pea, chickpea, lentil, linseed fenugreek, Saunf and carrot.
- Maintenance of soil fertility to help the plants to tolerate nematode damage.
- Application of Carbofuran @ 1 kg a.i./ha at the time of sowing with light irrigation for reducing crop damage.
- Cultivation of resistant wheat var. Raj 2184 and MR 1.
- Early or late sowing to help the plants to escape damage.



Molya diseased roots

Pigeonpea cyst nematode (*Heterodera cajani)*: *Heterodera cajani* is a pest of pigeonpea and pulse crops. Pearly white females are seen on the roots. Excessive branching at the point of infection, stunting and yellowing of the plant, and reduction in plant vigour and yield (10%) are also seen.

Control

Same as in the case of reniform nematode of pulses

Root knot nematode of vegetables (*Meloidogyne* sp.): *Meloidogyne* sp. is a pest of vegetables, pulses, cereals, and fruits. It is a parasite of roots; second-stage juveniles enter young roots and feed. The cells in the root-tissue enlarge and multiply repeatedly leading to the formation of knots or galls of various sizes on the roots. Sticky gelatinous egg-masses with about 500 eggs each are seen on the root surface. Vascular tissues are disrupted, causing reduction in translocation of nutrients and water. Yellowing of leaves, stunted growth of plants is seen in patches. Broad-leaved vegetables (cucurbits, brinjal etc.) exhibit temporary wilting during day time. Flowering, fruit production as well as fruit size are reduced. Patches of such poorly growing plants enlarge in area in the infested fields over the years. The disease spreads through infected seedlings and infested soil carried away with farm machinery, water and wind. It can cause yield reduction up to 20-30%.

Nematode infested brinjal roots with knots

Control

- Crop rotation for 1-2 years with non-host crops (Wheat, barley mustard, marigold).
- Summer fallowing and deep ploughing (2-3 times) in May-June at 10 days' intervals.
- In transplanted crops, soil solarization of area for nursery beds using clear, thin polyethylene mulch for 3-6 weeks is effective.
- Soil application of Carbofuran or Phorate @ 1 to 2 kg a.i/ha is also effective.
- Seed dressing with Carbosulfan (25% ST) @ 1-3% a.i./w/w or 5% neem-seed kernel powder for beans, okra and cucurbits.
- Use of resistant varieties of different vegetable crops will be effective and economical like SL 120 and Hisar Lalit of tomato.
- Bare-root dip treatment of seedlings with Carbosulfan or Triazophos @ 1000 ppm for 1 hour.
- Root treatment of seedlings of bhindi cowpea, bottle gourd, sponge gourd etc. before transplanting with carbufuran 25% ST @ 1-3% and neem kernel powder @ 5%.
- Growing trap crops like *Crotalaria spectabilis* for 1-2 months.
- Application of organic amendments such as FYM (10 t/ha) or deoiled neem-cake (0.5-1.0 t/ha) to soil 2-3 weeks before transplanting.

Leaf falls and yellowish leaves of nematode infested cucumber in polyhouse

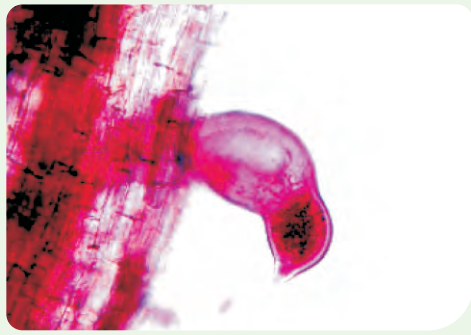
Okra field infested with root knot

Reniform nematode (*Rotylenchulus reniformis*): Young females are infective. The nematode feeds on cortex, pericycle, endodermis and phloem parenchyma. Roots with egg-sacs on surface appear dirty due

to adhering soil particles. Infected plants are stunted in growth with reduced and discolored root system. Damage during early crop growth period leads to poor crop stand and reduction in yield.

Control

- Crop rotation for 1-2 years with non-host crops (wheat, paddy, barley and mustard).
- Summer fallowing and deep ploughing (2-3 times) in May-June at 10 days' intervals reduce nematode population.
- Seed dressing with Carbofuran @ 1-3% a.i./w/w or 5% neem-seed kernel powder @ 5% w/w.
- Soil application of Carbofuran @ 1 kg a.i./ha is also effective.



Juice sucking nematode in the root of lemon

Citrus nematode (*Tylenchulus semipenetrans*): *Citrus nematode* causes slow decline of citrus and it is widespread in citrus plantations, occasionally infesting grapevine. It is mainly associated with citrus-orchards, all over the world. The infected trees slowly decline in growth. The foliage becomes pale and the leaves become small and fall prematurely. Heavy infestation is associated with declining orchards. Falling of leaves initiate from twigs and proceeds downwards, resulting in defoliated branching. Fruit number and size are reduced and may ripen pre-maturely. Curling and distortion of feeder roots, and thickening of infected portion occurs. Symptoms are visible in 3-4 years' old sick orchards.

Control

- Combination of neem cake @ 1 kg/plant and Carbofuran @ 2 kg a.i./ha reduces nematode population and increases yield.
- Bare root-dip treatments at 45^{0}C for 25 min or 47^{0}C for 10 min. can disinfect rootstocks of citrus seedlings.
- Rough lemons and trifoliate oranges (*Poncirus trifoliatae*) are resistant and are good material for rootstocks.

Citrus nematode infested lemon tree

Entomopathogenic nematode (A potential bio-agent against insect-pest): Entomopathogenic nematode, viz., *Heterorhabditis* sp. and *Steinernema* sp. are potential bioagents against major agricultural insect pests. Pusa Nemagel, a novel biopesticidal formulation of *S. thermophilum* with enhanced shelf life at high temperature conditions developed by the Institute could be used at wider scale. This formulation is easy to apply and can save on pesticidal usage and will be helpful for farmers to reduce the cost of cultivation. This formulation can also take care of termite problem in the field. These nematodes harbour pathogenic bacteria within them, which ultimately kill the insect pest by producing antibiotics and toxins in the insect body, once the nematodes enter them. Nemagel formulation has been commercialized with the help of NRDC.

Emergence of entomopathogenic nematode

8

Useful Agricultural Machines and Implements

The Institute has designed and developed a number of agricultural machines and implements for crop production and processing through which agricultural productivity can be increased by enhancing efficiency at low cost and less time. Some of these machines and implements are available on sale at the Institute. The technical details and estimated cost of the useful equipment are given below:

Implements of Weeding for Field Preparation

Pusa *Khurpa*

Pusa *Khurpa* is a heavy duty efficient equipment. Some weeds like *doob* (*Cynodon*), *bathua, amaranthus* (*Chaulai*), etc., can also be removed by this implement, which is not possible by simple kind of sickle and *khurpi*. Light branches can also be cut by this.

Technical details:

- Type of blade : 1.6 mm thick, made of carbon steel
- Handle : Made of *sisham* wood and handy
- Front edge : 18 cm x 8 cm
- Weight : 300 g
- Estimated cost : ₹ 45/-

Advantages:

- Inter-culture, weed removal and cutting can be performed easily.
- Suitable for different types of weeds including bushes.
- Less wear-off because of good quality steel.
- Efficient and easy to operate because of light weight.

Pusa Wheel Hoe

Pusa Wheel Hoe is a very simple and useful implement for weeding in between lines of standing crops by which very efficient and effective weeding is possible.

Technical details:

- Wheel diameter : 44 cm
- Handle length : 90 cm
- Power source : One person
- Weight : 7 kg
- Estimated cost : ₹ 400/-

Advantages:

- Useful for weeding and inter-cultural operations in row crops.
- Angle of operation could be adjusted according to the need.
- This can be used by giving forward and backward motion, which results in less fatigue.
- Cost effective for weeding and inter-cultural operations.

Sowing Machines

Pusa Aqua Ferti-Seed Drill

In India, more than 60% area is under dryland. Lack of proper soil moisture at root depth zone at the sowing time of *rabi* crops makes sowing difficult, which affects the germination and growth of crops. This machine has been invented for dryland areas. The machine makes possible the application of aqueous fertilizer, i.e., diluted solution of urea and DAP, etc., along side the seed, which helps in better germination and initial development of the crop. It is suitable for sowing of *rabi* crops like wheat, gram, mustard, etc. It is possible to apply 8,000-10,000 litres of aqueous fertilizer in a hectare by using this machine.

Technical details:

- Field capacity : 0.4 ha /h
- Power source : 45 HP tractor
- Weight : 225 kg
- Estimated cost : ₹ 75,000/-

Advantages:

- Timely sowing of *rabi* crops like wheat, gram, mustard, etc., in rainfed areas.
- Useful for dry land areas.
- An increase of 53% in germination and 35% in yield have been observed in wheat crop in comparison to traditional sowing.
- Uniform distribution of aqueous fertilizer helps in uniform germination.
- Efficient utilization of water and fertilizer with seed, and consumes about 10,000 litres of water/ ha.

Power Operated Maize Planter

The Power Operated Maize Planter is a very useful machine for farmers of small land holding and also for the farmers of hilly regions.

Technical details:

There is a seed control system in this machine, which is prepared by cell preparation on roller of nylon. Two systems of furrow digging and seed drilling are also developed in this machine.

- Capacity : 0.15 ha/h
- Power source : 3 HP petrol start Kerosene Engine
- Weight : 78 kg
- Estimated cost : ₹ 30,000/-
- Sowing of seed : Two rows

Advantages:

- It is a useful machine for small farmers because it is cheap and efficient. Planting can also be done in hilly areas.
- Row to row and plant to plant distance is maintained by using this machine.
- This machine saves time as well as seed while planting.

Pusa Pre-germinated Paddy Seeder

Pusa Pre-germinated Paddy Seeder has two forms - three lined and six lined.

Technical details:

Particulars		Three lined	Six lined
• Person	:	1-2	2
• Number of rows	:	3	6
• Distance between rows (cm)	:	15-25	15
• Capacity (ha/day)	:	0.2	0.4
• Estimated cost	:	₹ 3,000/-	

The paddy seed is soaked in water for 24 hours. After removing the water, the soaked seed is spread on gunny bags and is covered with wet gunny bags around 24-48 hours for germination of seeds. For proper sowing, the maximum length of plumules should be 0.5 cm. After that, it is sown in lines with this machine.

Advantages:

- Useful equipment for areas, where labour is a problem.
- Delayed sowing of paddy could be possible.
- Paddy sown with this machine matures 10-15 days earlier in comparison to transplanted paddy.

Pusa Seed Drill

Pusa Seed Drill is a useful equipment for small and marginal farmers, particularly those of hilly areas, for sowing of different crops. This is a relatively light weight equipment and can easily be shifted from one place to other. For cultivation in small plot sizes, particularly in hills, the tractor drawn seed drill is not suitable, and under such situation, small sized machines are useful.

Technical details:

- Field capacity : 0.15 ha/h
- Power source : 3 HP Engine (petrol start kerosene run)
- Weight : 98 kg
- Size of seed hopper : 35 cm x 35 cm
- Type of metering mechanism : Fluted roller type
- Diameter of wheel : 34 cm
- Estimated cost : ₹ 10,000/-

Advantages:

- Useful for farmers with small land holdings and for hilly regions.
- Seeds and fertilizer can be applied simultaneously.
- Row to row spacing and uniform seed rate is maintained.
- Saves seeds, time and increases yield by sowing through this machine.
- Height of furrow opener can be adjusted.
- Different row crops can be sown with this machine.

Tractor Operated *Okra* Planter

The tractor drawn *okra* planter is useful for sowing of wet *okra* seeds on top of the ridges. This implement consists of a seed box, a seed control unit, a bund formation unit, a frame and a ground wheel. A three-points control system is used for coupling with tractor.

Technical details:

- Number of ridges : 3
- Number of furrow openers : 3
- Seeding mechanism : Plate type
- Number of cells on the plate : 8
- Estimated cost : ₹ 25,000/-

Advantages:

- Saving of time and water as planting is done on ridges. This also increases the yield of the crop.
- Normally 2-3 seeds are planted at one place, thus it reduces seed rate.
- Row to row and plant to plant spacing is maintained.
- This implement covers one hectare of area in 5 hours, thus it saves 77 man-days and 35% of operational cost as compared to traditional method.

Machines of Harvesting and Threshing

Pusa *Okra* Seed Extractor

The Pusa *Okra* Seed Extractor facilitates the extraction of *okra* seed for seed purposes with minimum damage and high extraction efficiency. In this machine feeder unit, threshing unit and cleaning unit are put in frame. Various units of the machine are operated through belt and pulley drive system.

Technical details:

- Capacity : 70 kg/h
- Power source : 2 HP electric motor
- Weight : 175 kg
- Seed damage (Max.) : 4%
- Estimated cost : ₹12,000 /-

Advantages:

- Reasonably good capacity and efficient machine.
- Increase in germination due to less seed damage.
- Threshing time is reduced by 30% thus, operational cost is reduced by 70%.

Pusa Vegetable Seed Extractor

Traditional method of vegetable seed extraction is very difficult and time consuming with possible health hazards to labourers. Pusa Vegetable Seed Extractor is an ergonomically efficient machine, which increases the efficiency of seed extraction process.

Technical details:

The machine is available in both manually operated and power operated models. The manual machine is of low cost and it includes a rough-surfaced rotating cylinder, a metallic sieve and a hopper. The motor operated model of the machine is also available.

Manually Operated

- Input capacity : 60 kg/h tomato, 25-30 kg/h brinjal, 80-100 kg/h bottle gourd
- Power source : One person
- Weight : 60 kg
- Estimated cost : ₹ 7,000/-

Power Operated

- Input capacity : 500 kg/h brinjal, 450 kg/h bottle gourd, and 200 kg/h ash gourd
- Power source : 2 HP electric motor, single phase
- Weight : 125 kg
- Estimated cost : ₹ 30,000/-

Advantages:

- Suitable for efficient extraction of seeds of tomato, brinjal and bottle gourd.
- Use of this machine prevents skin problems/injuries to hands and legs, which are prevalent in traditional methods.
- Vegetables are directly fed into the machine unlike in traditional method where vegetables are stored for 24 hours for seed extraction.
- The powered version of this machine is suitable for commercial vegetable seed growers.

Post Harvest Technology

Power Operated Paddy Milling Machine

The farmers can increase their income by milling paddy into rice grains at village and field level. The Power Operated Paddy Milling Machine has been developed for the purpose of milling paddy into rice grains by the farmers .

Technical details:

Removal of husk from paddy by the use of two rubber rollers is done to retain its vitamins. The husk is separated from the rice by using a blower, by which cleaning work is automatically done.

- Capacity : 40 kg/h
- Power source : 1.5-2.0 HP electric motor
- Weight : 50 kg
- Estimated cost : ₹ 7,500/-

Advantages:

- Broken rice is less.
- Nutrient value of rice is maintained, since only the husk is removed from the rice.
- Useful machine for small farmers.

Pusa Rice Grading Machine

The Pusa Rice Grading Machine adds quality to the produce. Using this grading machine, a farmer can get different sizes of rice grains. Small farmers can do grading of rice at village level, and earn more money.

Technical details:

- Capacity : 150 kg/h
- Power source : 1 HP motor
- Estimated cost : ₹ 10,000/-

Advantages:

- All varieties of rice can be graded by the machine.
- Grading improves the quality of the product and helps in value addition.
- Grading fetches more value in the market.
- Requires less labour and cost.

Mobile Animal Feed Block Formation Machine

Animal feed blocks can be made by using the Mobile Animal Feed Block Machine in the field itself. The mobility facilitates the formation of feed blocks at a location of convenience. The blocks can be stored for a period of one year. Transportation becomes easy owing to reduction in volume.

Technical details:

There are three main components: a frame, two hydraulic cylinders, and a power pack. The major specifications are as follows:

- Capacity : 100-125 kg/h, block size 15 cm x15 cm
- Power source : 6.5 HP diesel engine
- Weight : 1500 kg
- Estimated cost : ₹ 5,00,000/-
- Trolley size : 3 m x 1.5 m
- Block size : 15 cm x 15 cm

The weight of blocks ranges between 0.50 kg and 2.5 kg

Advantages:

- Animal feed or straw is reduced to 1/7th of its original volume, which results in less storage and transportation cost.
- Being portable, this machine can be used to make blocks wherever animal feed is available.
- Nutritious ingredients present in the feed make it a complete animal feed.
- The feed blocks can be stored for about one year so that feed is available to the animal throughout the year, especially in areas where natural calamity occurs.

Urea, Mollasses and Minerals Block (UMMB) Forming Machine

UMMB machine is used for mixing minerals (in powder form) in proper quantity along with animal feed blocks. The following ingredients are used in block formation:

- Mollasses : 35 %
- Urea : 10 %
- Broken rice : 35 %
- Groundnut : 10 %
- Cement : 6 %
- Minerals : 3 %
- Salt : 1 %

The specific details of the machine are as follows:

Technical details:

- Capacity : 150 kg/h
- Block size : 22.5 cm x 4.5 cm
- Weight : 200 kg
- Power source : 1 HP
- Estimated cost : ₹ 6,500/-

Advantages:

- The blocks fulfil the energy and protein requirement of animals.
- Feeding milking animals with 200-300 g of this feed, increases their milk production.

Pusa Animal Feed Block Formation Machine

The animal feed block formation machine has been developed for making appropriate sizes of animal feed blocks by mixing crop residues with essential nutrients. These nutrient rich feed blocks are very useful in those areas where fodder is not available. The blocks have a shelf life of one year.

Technical details:

Frame: Contains a feeding chamber, a compression chamber, and a feed block die.

Hydraulic cylinder: There are two hydraulic cylinders of different sizes in the machine. The larger cylinder is for compression of feed and the smaller cylinder for opening and closing the gate of compression chamber.

Power pack: Contains a high and low pressure pump, a pressure switch, a solenoid bulb, an oil tank, etc. The hydraulic cylinders are operated by high and low pressure pumps. Moving direction of the cylinder is monitored by solenoid valve.

Electric control panel: Regularizes the movement time of hydraulic cylinder.

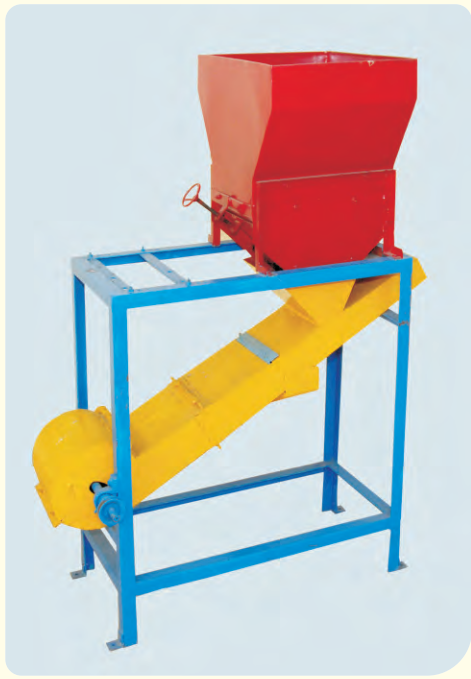
- Capacity : 200-250 kg/h, block size 20 cm x 20 cm
- Power source : 25 HP electric motor
- Weight : 400 kg
- Estimated cost : ₹ 9,00,000/-
- Main parts : Frame, hydraulic cylinder, electricity control panel

Advantages:

- The machine can make different sizes of feed blocks for animal feed as well as blocks of paddy straw.
- Easy to operate by a semi-skilled operator.
- Using this machine, crop straw/crop residues can be converted into blocks, which increases its shelf life.
- It is very economical because transport to far-off places becomes easy.

Power Operated Winnower

Cleaning of the produce is one of the important steps in grain processing and value addition. The Power Operated Winnower has been developed for this purpose.



Technical details:

- Capacity : 300-600 kg/h
- Power source : 1 HP electric motor
- Blower speed : 1440 rpm
- Size of grain hopper : 12" x 12"
- Weight : 40 kg
- Estimated cost : ₹ 5,000/-

Advantages:

- Enhances the quality of produce and cleaning becomes of high quality.
- Exhaust air blows off the dust and unwanted particles and the final product is collected.
- All grains can be cleaned by using this equipment.
- Two or more mixed grains can be separated by using this machine.
- Saves money and time.

Mini *Dal* Mill

The Mini *Dal* Mill is a useful machine for small and marginal farmers. The farmers can convert their pulse produce into value added products and enhance their income. The machine has a provision to separate pulse grain into two pieces. The husk is removed by using a blower. The speed of the blower can be varied depending on the requirement.

Technical details:

- Capacity : 60-80 kg/ha
- Power source : 2 HP (3-phase electric motor)
- Weight : 100 kg
- Estimated cost : ₹ 15,000/-

Advantages:

- The machine can be used for making *dal* of chickpea, pigeonpea, lentil, soybean, black gram, green gram, etc.
- Cleaning and sorting of *dal* could be done simultaneously.
- Excellent machine for village level use and for small farmers.
- Breakage of grain is very less.

Pusa Compost Turner cum Mixer

The Pusa Compost Turner cum Mixer Machine is useful for thorough mixing of cowdung, farm residues and biomass for preparation of good quality compost.

Technical details:

- Power source : 70 hp tractor
- Capacity : 3,000 tonnes per day
- Approximate cost : ₹ 4,00,000/-
- Estimated income : ₹ 10-15 lakh per annum
- Advantages : Save one month time in compost making as compared to traditional method
- Payback period : 24 months

Pusa Compost Loader

The Pusa Compost Loader is useful for lifting and carrying compost material up to a height of 3 m and loading the compost/ FYM in trucks and tractors.

Technical details:

- Power source : 55 hp tractor
- Capacity : 12 tonnes per hour
- Approximate cost : ₹ 2,75,000/-
- Advantages : The loader takes only 0.5 machine hour for loading a truck where as 15 man-hr is required for manual operation
- Payback period : 14 months

Pusa Compost Sieving Machine

The Pusa Compost Sieving Machine is useful for separating compost into the finer grade and coarse grade.

Technical details:

- Power source : Three phase Electric motors (2 hp, 3 hp and 3 hp)
- Capacity (estimated) : 5 tonnes per hour
- Approximate cost: ₹ 5,00,000/-
- Advantages : Separation in different sizes for value addition (Smaller grades are used in pots)
- Payback period : 30 months

9

Advisory Services for Farmers

Advisory Services for Farmers

Fast and efficient dissemination of suitable technological information from the agricultural research system to the farmers' field and reporting of farmers' feedback to the research system is one of the critical functions in transfer of technology. The importance of appropriate information package and its dissemination has assumed greater significance in this "information age".

Agricultural information and advisory services through ATIC

The Institute's Agricultural Technology Information Centre (ATIC) is a single window support system linking various units of the Institute with intermediary and end users in decision making and problem solving. The ATIC is serving farmers through single window, which enables farmers to have the required products, services, technologies and information at one place. Following services are available at the ATIC:

Sale of Technology Products

Seeds of field, vegetable and other horticultural crops

Bio-fertilizers

Small agricultural implements

Agricultural literature

Diagnostic Services

Plant health clinic

Soil and water testing through soil testing lab

Pusa Helpline

Agricultural Information through Pusa Helpline, 011-25841670 available from 9:30 AM to 4:30 PM in working days.

Pusa Agricom

Toll Free *Kisan* helpline 'Pusa Agricom' (**1800 11 8989**) for the use of collaborative partners, and other stakeholders from all over the country (9:30 AM to 4:30 PM in working days).

Kisan Call Centre

Second level of *Kisan* Call Centre (**1800 180 1551**) for the farmers of Delhi.

Farm advisory services and remedial measures for farmers' problems

Farm advisory services and remedial measures for farmers' problems and supply of information on agricultural related subjects and agro-based enterprises to farmers and other visitors.

Weather based-agro advisory services for farmers.

CDs, audio and video cassettes of crops and other agriculture related enterprises are available for farmers.

Touch Panel Kiosks

Facility to visitors for getting information of the Institutes' latest technologies through touch panel kiosks.

Gobar Gas Unit

Gobar gas unit has been established at ATIC for information to the farmers so that they can use this technology at large scale to save fuel.

NCDEX Price Index Board

Display of the latest rates of agricultural commodities in various agricultural markets and anticipated rates for three months.

Information through letters/e- mail

Farm information is also being sent through letters/e-mails in response to farmers' queries. Remedial measures for their problems are also suggested through postal correspondence.

Crop cafeteria

Live demonstration on latest varieties of various *rabi* and *kharif* crops, vegetable crops, fruit trees and some important medicinal plants.

Sale of extension magazine, pamphlets, and other publications

A list of publications available in ATIC along with the price is given below:

Price list of available agricultural literature

S.No	Name of the publication	Rate (₹)
1.	*Prasar Doot* (Quarterly Magazine) Annual Fee	₹ 15.00 ₹ 60.00
2.	*Rabi Fasalon Ki Unnat Takaniki*	₹ 20.00
3.	*Kharif Fasalon Ki Kheti*	₹ 30.00
4.	*Phal, Evam Phoolon Ki Kheti*	₹ 30.00
5.	*Sabzi Phasal Utpadan Ki Taknikiyan*	₹ 30.00
6.	*Government Support and Facilities for Farmers and Rural Development (English)*	₹ 10.00
7.	*Krishi aur Gramin Vikas Yojnayein Evam Suvidhayein (Hindi)*	₹ 30.00
8.	*Kisan Jigyasa Evam Samadhan*	₹ 20.00
9.	*Parinagariya Kheti*	₹ 100.00
10.	Technological Option for Enhanced Productivity and Profit (English)	₹ 200.00
11.	*Uchcha Utpadan Evam Aay Hetu Unnat Krishi Proudyogikiyan (Hindi)*	₹ 200.00
12.	Kharpatwar Niyantran Se Phasal Suraksha	₹ 50.00
13.	Pamphlets (for all arable & vegetable crops)	free of cost

Agricultural extension programmes and services through CATAT

The Institute has developed various extension approaches and strategies, which have played a very important role in the transfer of agricultural technology in the country. Starting with Intensive Cultivation Scheme, the Institute had taken the initiative in evolving projects like National Demonstration Project, Operational Research Project, Seed Village Scheme, Mini-Kit Programme, Small and Marginal Farmers' Development Programme, Integrated Whole Village Development Approach, Single Window System, and Farmer-to- Farmer Quality Seed Production Programme. At present the Institute has undertaken 'National Extension Programme' and 'IARI-NGO Collaborative Programme' for developing integrated extension models for market-led agriculture at national level.

Transfer of technology programme of the Institute is operational in different states of the country like U.P. (Fatehpur, Banda, Sultanpur, Mirzapur, Meerut, Allahabad, Varanasi, Gazipur, Lakhimpur, Aligarh, Bulandshahar and Ghaziabad), Uttarakhand (Uttarkashi), Bihar (Munger), Chhattisgarh (Raigarh), and Rajasthan (Sikar and Jhunjhunu).

National Extension Programme of Institute

The Institute initiated the National Extension Programme in 2007 in collaboration with selected agricultural universities and ICAR institutes. Besides transfer of improved technology, the programme aims at initiating community approach for integrated agriculture by facilitating farmer to farmer transfer of farm technologies. The salient features of this programme are as under:

Peri-urban agriculture (up to 75 km from IARI)

Integrated agricultural development (75 to 500 km from IARI)

Agricultural development programme in collaboration with SAUs / ICAR institutes / BHU (>500 km from IARI)

IARI-NGO Collaborative Programme

The Institute has undertaken a partnership programme with selected NGOs for feasibility trials and promotion of agricultural technologies in their operational locations, a first of its kind in public-private partnership for agricultural transformation. Under this programme, 27 NGOs of repute from 16 states of the country are involved to assess and disseminate IARI technologies in their operational areas. A toll free service (1800 11 8989) has been launched by IARI to facilitate communication with NGO partners.

Krishi Vigyan Mela

Krishi Vigyan Mela is organized every year for three days during February/March with the following major attractions :

Live demonstrations on scientific crop production technologies, including protected cultivation, technologies for *rabi* cereals, oilseeds, pulses, vegetables and flowers.

Display of improved varieties of vegetables, flowers, and horticultural technologies.

Protected cultivation of vegetables and flowers for higher returns.

Demonstrations on improved irrigation technologies.

Display of farm equipments and machinery.

Free soil and water samples analysis for farmers.

Exhibition and sale of agricultural produce and value added products directly by farmers themselves.

Sale of seeds of high yielding varieties (HYVs) of crops, saplings and seedlings by IARI and other participating public and private organizations.

Display and sale of fertilizers and agro-chemicals by different public and private agencies.

Direct interaction between scientists and farmers (*kisan gosthi*).

Display and sale of farm literature.

Farmers' visit to experimental fields of IARI.

Farm women empowerment workshop.

Innovative farmers' meet.

Awards to Progressive farmers.

Akashwani/Krishi Darshan Pathshalas

Akashwani/Krishi Darshan Pathshalas are organised by the Institute on different crops and their production technologies from time-to-time in collaboration with All India Radio, New Delhi, and Delhi Doordarshan.

In the *pathshalas*, farmers from all over the country are invited to register themselves.

The crop specific scientific production technologies are broadcasted/telecasted regularly.

Prizes are given at the end of broadcast of *krishi pathshalas* to the farmers who answer correctly to the questions asked from the lessons taught.

Vocational models for self employment

The Institute's Krishi Vigyan Kendra (KVK) at Shikohpur (Gurgaon) has substantially contributed in providing vocational trainings in self-employment to rural youth. The KVK has developed several models based on income and expenditure of vocational training, the details of which are given below:

Commercial models : Description of expenditure and net income

Bee-keeping : With 20 bee colonies and investing ₹ 80,000 in the first year, a farmer can have a net profit of ₹ 25,000, ₹ 50,000 and ₹ 90,000 in the first, second and the third year, respectively.

Motor winding : With an initial expenditure of ₹ 30,000 to be incurred for procuring hand tools and accessories for setting up a motor winding workshop, one can earn up to ₹ 60,000 per year as net profit.

Tractor repairing : To establish a tractor workshop initially, an amount of ₹ 1,00,000 has to be invested, through which, one can earn ₹ 1,20,000 as net profit per year.

Protected farming: From a poly house of 500 m^2, established with an initial expenditure of ₹ 1,00,000 for cultivating off-season vegetable seedlings, one can earn up to ₹ 1,20,000 per year as net profit.

Vermicompost : Ten beds (3'x10') of vermicompost are prepared with an investment of ₹ 30,000 and in 90 days duration, an amount of ₹ 35,000 can be earned through sale of worms and vermicompost (@ ₹ 5 per kilogram) provided, one can find market and earn ₹ 1,40,000/- per annum.

Dress designing & stitching : With an investment of ₹ 50,000 initially on sewing machine and accessories for setting up of a rural tailoring shop, rural women can earn up to ₹ 1,20,000 per year.

Preservation of seasonal fruits & vegetables : After incurring an initial expenditure of ₹ 25,000 on essential materials and tools for preservation of seasonal fruits and vegetables, rural women can earn up to ₹ 80,000 per year as net benefit through retail sale of the produce.

10

Useful Information for Farmers

List of IARI Seeds and Planting Materials with Sale Prices

A. Field Crops

S. No.	Crops	Varieties	ICAR price for breeder seed (₹/kg)	Price of IARI seed (₹/kg)
1.	Maize	Composite	35.00	32.00
		Ganga 11 (Hybrid)	–	38.00
		Pusa Early Maize Hybrids 1,2,3,4 & 5	–	38.00
		Parental Lines	130.00	**
2.	Paddy	PRH 10 (Hybrid)	–	200.00
		Hybrid A Line B Line R Line	 1,75.00 36.00 36.00	 ** ** **
		Pusa Basmati 1121 (Pusa Sugandh 4) Pusa Basmati 6 (Pusa 1401)	60.00	55.00
		Pusa Basmati 1 Improved Pusa Basmati 1		50.00
		Pusa Sugandh 2 Pusa Sugandh 3 Pusa Sugandh 5 (2511)		45.00
		Pusa 834, PNR 162, PNR 381 PNR 542 (JD-6) Pusa 44	36.00	28.00
3.	Wheat	All *Aestivum* varieties (including WR 544)	38.00	30.00
		Durum varieties *Dicoccum* varieties	38.00	33.00
		Desi varieties	42.00	35.00
4.	Barley	Malt barley	22.00 24.00	20.00 22.00
5.	*Bajra*	Varieties & composites Hybrids Hybrids A Line B Line R Line	70.00 – 160.00 80.00 80.00	60.00 65.00 ** ** **
6.	Pigeonpea *(Arhar)*	All varieties	90.00	85.00
7.	Cowpea *(Lobia)*	All varieties	70.00	60.00
8.	Field pea	All varieties	50.00	46.00
9.	Gram	*Desi* type *Kabuli* type	65.00 90.00	60.00 80.00

10.	Lentil	All varieties	65.00	60.00
11.	*Moong*	All varieties	90.00	85.00
12.	Cotton	Parental lines of Hybrid	480.00	**
		Male Sterility System Based A Line	600.00	**
		R Line	600.00	
		All varieties	150.00	140.00
	Delinted cotton	Parental lines	600.00	**
		All varieties	187.50	180.00
13.	Mustard	All varieties	65.00	60.00
14.	Soybean	All varieties	60.00	55.00
15.	Fodder Sorghum	PC 6/PC 9/PC 23, etc.	60.00	55.00
16.	*Berseem*		240.00	200.00

* Prices inclusive of packaging charges; ** similar to ICAR fixed prices

B. Vegetable Crops

S. No.	Crops	Varieties	ICAR price for breeder seed (₹/kg)	Price of IARI seed * (₹/kg)
1.	*Methi*	Pusa Kasuri/PEB	110.00	100.00
2.	*Palak*	PJ/AG/Pusa Bharti and other varieties	100.00	70.00
		Pusa Harit		90.00
3.	Spinach	Virginia Savoy	220.00++	120.00
4.	Amaranth	All varieties	220	200.00
5.	*Bathua*	Pusa Bathua No.1	–	150.00
6.	Lettuce	Great Lake/Chines Yellow	600.00++	500.00
7.	Parsley	Moss Curled	–	200.00
8.	Celery	Ford Hook Emperor	–	200.00
9.	Okra	A 4/ Pusa Sawani/Pusa Mukhmali/ Perkins Long Green	220.00	180.00
10.	Brinjal	All varieties	720.00	700.00
11.	Chillies	Pusa Jawala/Pusa Sadabahar	770.00	700.00
		Paprika/KTPL-19	2,000.00	800.00
12.	Capsicum (Sweet pepper)	CW/YW	2,200.00	1,800.00
		Pusa Deepti (KT-1)		20,000.00
		KTC PH 3 Hybrids		

S. No.	Crops	Varieties	ICAR price for breeder seed (₹/kg)	Price of IARI seed * (₹/kg)
		Parentals lines of Pusa Deepti Hybrid KTC PH 3 Hybrid Female/Male	25,000.00	**
13.	Tomato	Roma/Pusa Uphar/Pusa Sadabahar/Pusa Rohini PR/PED/Sioux/Marglobe/Best of all/Pusa 120/ Pusa Diviya Hybrid, Pusa Hybrids 1, 2, 4, 8 Parental lines of Pusa Diviya Hybrid Female/ Male	1,540.00 35,000.00 25,000.00++	1,400.00 1000.00 20,000.00 **
14.	Cowpea	Pusa Sukomal/Pusa Komal/Other varieties	150.00	140.00
15.	Dolichous bean	PEP/Pusa Sem 2/Pusa Sem 3	170.00	140.00
16.	French bean	Contender & other varieties	170.00	150.00
17.	Winter bean	Pusa Sumeet	100.00	90.00
18.	Garden pea	All Varieties	110.00	80.00
19.	Cauliflower	Pusa Early Synthetic/Pusa Synthetic/Pusa Sharad Pusa Meghna/Pusa Deepali/IJ/Pusa Himjyoti/and other new varieties	1,100.00	1,000.00
		Pusa Hybrid 2 & Pusa Kartik Sankar	–	5,000.00
		Snowball types (PSB 1/PSBK 1/KT 25, etc.)	2,750.00	2,500.00
		Parental lines of Hybrid Female/Male	12,000.00	**
20.	Cabbage	Golden Acre/PM/PDH/Pusa Ageti Hybrid 1 (KGMR 1)	720.00 –	700.00 6,000.0
		Parental lines, Female Male	20,000.00 ++ 10,000.00 ++	20,000.00 10,000.00
21.	Knol-Khol	White Viena	440.00	400.00
22.	Brussels Sprout	Hild Ideal	2500.00 ++	2,000.00
23.	Broccoli	KTS 1	2,500.00 ++	2,000.00
24.	Radish	All varieties	330.00	300.00
25.	Turnip	All varieties	280.00	270.00
26.	Carrot	Pusa Kesar/Pusa Meghali	440.00	350.00
		Nantes/Pusa Yamdagni Pusa Rudhira and all new varieties		400.00
		Pusa Nayanjyoti (Hybrid)		800.00
27.	Garden beet	DDR/Crimson Globe	600.00 ++	400.00
28.	Onion	All varieties	660.00	600.00

S. No.	Crops	Varieties	ICAR price for breeder seed (₹/kg)	Price of IARI seed * (₹/kg)
29.	Bottle gourd	All varieties/PSPL/PN/PS	390.00	350.00
		Pusa Hybrid 3	–	1,800.00
		Parental lines of Female/Male	2,000.00	**
30.	Bitter gourd	PDM/Pusa Vishesh	500.00	450.00
		Pusa Hybrids 1 & 2		2,000.00
		Parental lines of Female/Male	2,500.00	**
31.	Sponge gourd	All varieties	390.00	350.00
32.	Ridge gourd	Pusa Nasdar	390.00	350.00
33.	Ash gourd	Pusa Ujwal	750.00	500.00
34.	Cucumber	Pusa Uday/Japanese Long Green	880.00	800.00
		Pusa Sanyog (Hybrid)		2,500.00
		Parental lines of hybrids Female	20,000.00	**
		Male	15,000.00	**
35.	Muskmelon	Pusa Madhuras/Pusa Sharbati	550.00	450.00
		Pusa Rasraj (Hybrid)		5000.00
		Parental lines of Female/Male	6,000.00	**
36.	Watermelon	SB/AY	600.00	550.00
37.	Pumpkin	Pusa Vikas/Pusa Vishwas	500.00	450.00
		Pusa Hybrid 1		2,000.00
		Parental lines of Female/Male	2,500.00	**
38.	Squash	Australian Green	–	700.00
		Pusa Alankar (Hybrid)	–	1,500.00
		Parental lines of Pusa Alankar Female/Male	2,500.00	**
39.	Snap melon	Pusa Shandar	–	250.00
40.	Vegetable mustard	Pusa Sag 1	–	120.00
41.	Seedlings of vegetables, e.g.	OP varieties	–	₹ 20/100
	tomato, chilli, brinjal, cauliflower	Hybrids	–	₹ 40/100
	and other cole crops	Onion	–	₹ 25/kg

* Prices inclusive of packaging charges; ** Price fixed by ICAR; ++ Price fixed by IARI P.F.C.

C. Flower Crops

S. No.	Crops	Varieties	ICAR price for breeder seed (₹/kg)	Price of IARI saplings/seeds*
1.	Amaryllis	Surya Kiran	–	₹ 10/bulb
2.	Annual flowers	Bold seeded**	–	₹ 20/5g
		Small seeded	–	₹ 15/1g
3.	Bougainvella	All types	–	₹ 15/plant
4.	Chrysanthemum/ Dahlia cuttings	Bare rooted	–	₹ 2/plant
5.	Rooted plant in polythene bag		–	₹ 4/plant
6.	Gladiolus	Corm	–	₹ 5/corm
7.	Marigold	African varieties PNG/PBG	₹ 6,000.00++	₹ 5,000/kg
		French varieties		₹ 3,000/kg
8.	Nargis	Bulb	–	₹ 3/bulb
9.	Rose	Climber/Miniature	–	₹ 35/plant
		Cutting (Un-rooted)	–	₹ 50/hundred
		Cutting (rooted)	–	₹ 100/hundred
		HT/Floribunda	–	₹ 50/plant
		HT/Floribunda (in plot)	–	₹ 70/plant
		Standard	–	₹ 2/bud
		Rose (bud)	–	₹ 60/plant
10.	Tuberose	Double	–	₹ 3/bulb
		Single	–	₹ 2/bulb
11.	Dahlia	Bulb	–	₹ 3/bulb

* Price inclusive of packaging charges

** Bold seeded *viz.,* Calendula, Nausturatatium, Larkspur, Wallflower, Annual Chrysanthemum, Molucella Dimorphothica, Annual Dahlia

++ Price fixed by IARI P.F.C.

D. Fruit Plants

S. No.	Crops	Varieties	ICAR price for Breeder Seed (₹/kg)	Price of IARI saplings/seeds*
1.	Apple	Root stock	–	₹ 10/plant
2.	*Ber*	Buds	–	₹ 2/stick of 3-5 buds
		Budded plant in all 4 varieties	–	₹ 20/plant
3.	Citrus, Grape & *Mousambi*	Kagzi Kalan, Grape Fruit & Mousambi	–	₹ 25/plant
		Kinnow	–	₹ 40/plant
		Kinnow, Grape and Mousambi (bud)	–	₹ 2/stick of 4-6 buds
4.	Grapes	All hybrid varieties including Navrang and Urvashi hybrids	–	₹ 10/plant
5.	Guava	Allahabad Safeda	–	₹ 25/plant
		Root stocks of Pusa Srijan	–	₹ 100/-

S. No.	Crops	Varieties	ICAR price for breeder seed (₹/kg)	Price of IARI saplings /seed * (₹)
6.	Kiwi	All varieties	–	₹ 25/plant
7.	Mango	Amrapalli/Mallika (hybrid)	–	₹ 50/plant
		Pusa Arunima (hybrid)/ Pusa Surya	–	₹ 60/plant
		Scion stick of hybrid	–	₹ 4/Scion
8.	Papaya	All varieties (saplings)		₹ 5/sapling
		All varieties (seed)	₹ 40,000/kg++	₹ 30,000/kg
9.	Peach	Florida Sun	–	₹ 25/plant
10.	Strawberry	All varieties	–	₹ 2/runner

* Prices inclusive of packaging charges
++ Prices for breeder seeds fixed by IARI P.F.C.

Places from where seeds can be obtained

Farmers can obtain the seeds of improved varieties developed by the Institute from the Seed Production Unit and Agricultural Technology Information Centre (ATIC) located at IARI campus from 9.30 AM to 4.30 PM on all working days.

Address of IARI

Indian Agricultural Research Institute (IARI)
New Delhi 110 012
Phone: 011-25733367, 25843375
011-25841670 (ATIC)
011-25842686 (Seed Production Unit)
Fax: +91-11-25846420
Website: www.iari.res.in

Farmers may also contact the following Regional Stations of the Institute

IARI Regional Stations

IARI Regional Station, Karnal, Haryana
Phone No.: 0184-2267169

IARI Regional Station, Pusa, Samastipur, Bihar
Phone No.: 06274- 240232

IARI Regional Station, Indore, Madhya Pradesh
Phone No.: 0731-2702921

IARI Regional Station, Katrain, Kullu Valley, H.P.
Phone No.: 01902-241280

Required quantity of chemical fertilizers against recommended doses

According to the recommended doses of nutrients, mentioned in this book, the quantity of chemical fertilizers required is as follows:

Recommended dose of nitrogen (kg/ha)	Required dose of urea (kg/ha)	Recommended dose of phosphorus (kg/ha)	Required dose of SSP (kg/ha)	Recommended dose of potash (kg/ha)	Required dose of muriate of potash (kg/ha)
20	45	20	125	20	43
40	90	40	250	40	66
60	135	60	375	60	99
80	180	80	500	80	132
100	220	100	625	100	165

Diammonium phosphate (DAP) is a very popular fertilizer, which provides two nutrients, i.e., nitrogen (18 kg) and phosphorus (46kg) through 100 kg DAP. Farmers should use DAP according to the recommended quantity of phosphorus and meet the remaining nitrogen requirement through the urea.

Besides the above three nutrients, sometimes there is a need to spray the following micro-nutrients :

Name of micro-nutrient	Chemical source	Quantity (kg/ha)
Zinc (Zn)	Zinc Sulphate	15 - 20
Iron (Fe)	Ferrous Sulphate	10 - 15
Manganese (Mn)	Manganese Sulphate	15 - 20
Copper (Cu)	Copper Sulphate	15 - 20
Molybdenum (Mo)	Sodium Molybdate	0.5 - 1.0
Boron (B)	Borex	2 - 5

Agricultural chemicals developed at IARI

Pusa Hydrogel: Developed for enhancing the productivity of available water, suitable for low humidity and low water availability regions. Rate of application in soils is 1-2 kg/ha for horticultural crops, and 2.5-5 kg/ha for field crops.

Neem based Azadirachtin-A concentrate: Neem fruit, kernel, and cake based concentration used as bio-pesticide and do not harm the environment and wild life.

Important agro-chemicals

Insecticide	Fungicide	Bactericide	Acaricide	Rodenticide	Herbicide
Monocrotophos	Mancozeb	Streptomycin	Dicofol/Kelthane	Zinc phosphide	Isoproturon
Malathion	Sulphur dust	Tetracycline		Bromadiolone	Butachlor
Carbaryl	Copper sulphate	Validamycin			2,4 - D
Chlorpyriphos	Carbendazim	Sheathmas			Anilophos
Quinalphos	Thiram	(Validamycin 3% L)			Atrazine
Phorate	Copper oxychloride	Agrimycin			
Imidacloprid		Kasu-B (Kasu-			
Indoxacarb		gamycin 3% SL)			
Cartap hydrochloride					

Agro-chemicals banned or restricted for use in India

Aldrin	B.H.C.	Calcium cyanide	Chlordane
D.D.T.*	Lindane*	Sodium cyanide*	Ethyl Mercury Chloride
Copper acetoarsenite	Dibromochloropropane	Endrin	Nicotin sulphate
Ethyl Parathion	Heptachlor	Menazone	Pentachlorophenol
Nitrofen	Paraquat Dimethyl Sulphate	Pentachloro Nitrobenzene	Toxafen
Phenyl Mercury Acetate	Sodium Methane Arsonate	Tetradifon	

Aluminium phosphide*
Carbofuran 50% SP
Captafol 80% powder
Methyl Parathion (2% powder) & 50% E.C.*
Methoxy Ethyl Mercury Chloride (Recommended only as pre-sowing treatment of potato and sugarcane)*
Aldicarb
Chlorobenzilate
Dieldrin
Ethyene Dibromide
Maleic Hydrazide
Trichloro Acetic Acid
Methyl Bromide*
Phosphamidon (85% SL)
Methomyl (24% L)
Methomyl (12.5% L)
Monocrotophos (banned in vegetable crops)*
Endosulfan*

* Restricted use

Registered biopesticides and botanical chemicals for plant protection under Govt. of India"Insecticide Act, 1968"

Biopesticides (bio-insecticides), antagonistic bacteria and formulation of fungi

Antagonistic bio-formulation

Bacterial		Fungal
Bacillus based	*Trichoderma based*	*Pseudomonas based*
Bacillus thuringiensis var. *israelensis* strain 164 (Serotype H-14 WP)	*Trichoderma viride* WP	*Pseudomonas fluorescens* (1.25% WP)
Bacillus thuringiensis var. *kursaki* strain A97 (Serotype H-3A, 35 WP)	*Trichoderma viride* 1.0% WP	
Bacillus thuringiensis var. *israelensis* strain VCRC E-17 (Scrotype H-14 slow release granules)	*Trichoderma viride* 0.5% WS	
Bacillus thuringiensis var. *israelensis* strain VCRE B-17 (Serotype H-14 WP)	*Trichoderma harzianum* 0.50% WS	
Bacillus thuringiensis var. *israelensis* (WS)	*Trichoderma* 1.15% WP	
Bacillus thuringiensis var. *israelensis* (serotype H-14, 12 AS)		

Precautions at the time of chemical application

Use chemicals as per recommended dose.

Use chemicals in morning hours and dry weather.

Use chemicals as per directions given on the bottle /packet of chemical.

Keep the chemicals away from children.

Use gloves and goggles, and cover nose and mouth while using chemical spray.

Do not spray chemicals during fast wind.

Spray towards the direction of wind.

Wash the clothes after spray.

Wash body immediately if spray by chemical.

Do not use empty chemical boxes for storing.

Wash the parts of the body touched by chemical. In case of physical problem during chemical spray seek medical aid.

Agriculture related weight and measurement information

1 Hectare = 10,000 m^2

1 Hectare = 2.471 Acre

1 Hectare = 50 Nali

1 Acre = 0.4047 Hectare

1 Acre = 4,840 $Yard^2$

1 Nali = 200 m^2

1 m^3 = 1,000 Litre

1 Hectare-CM Water = 1,00,000 (1 Lakh) Litre

1 Quintal = 100 Kilogram

1 Tonne = 1,000 Kilogram

1 P.P.M. = 1 Milligram per Kilogram

1 Percentage = 100^{th} part of quantity