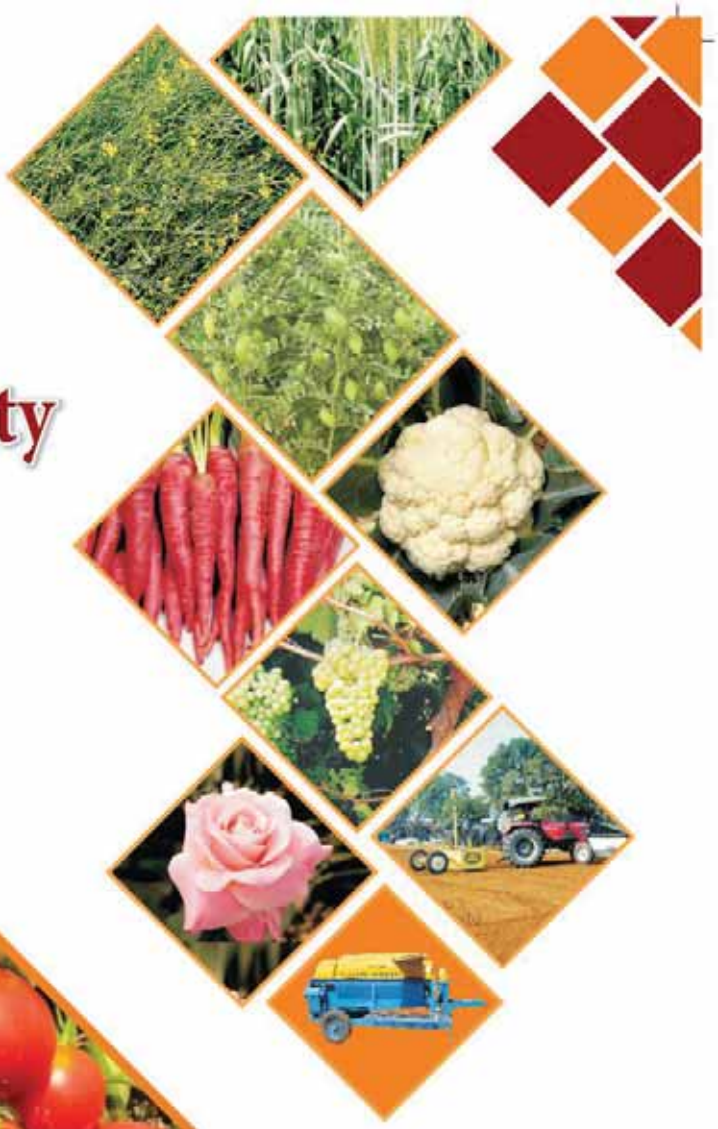
Technological Options for Enhanced Productivity and Profit



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Technological Options for Enhanced Productivity and Profit

Third Revised Edition

Indian Agricultural Research Institute
New Delhi - 110 012

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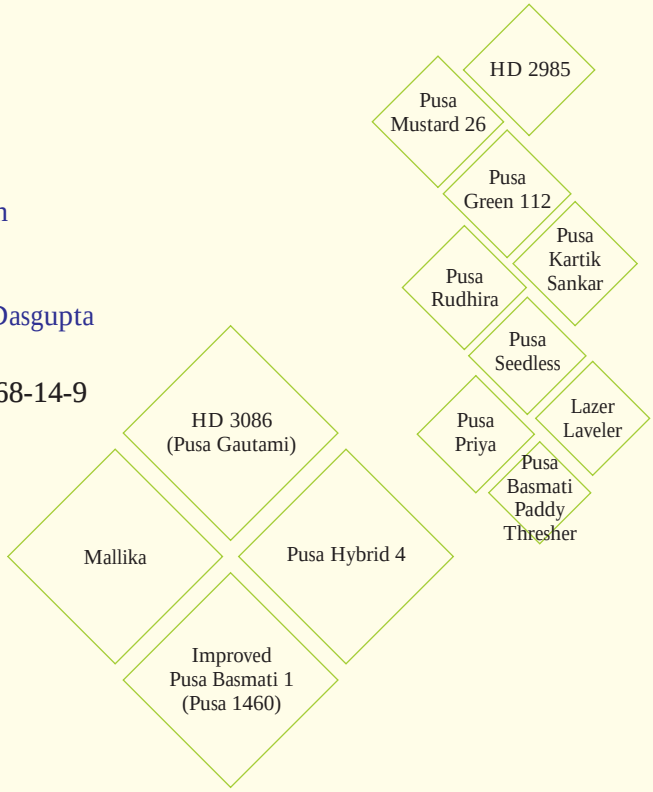

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शरद पवार
SHARAD PAWAR

सत्यमेव जयते

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

MESSAGE

Agriculture holds the key to nation's stride towards attaining its avowed objectives of food security, poverty alleviation and inclusive growth. The committed endeavors in agricultural research and development have helped transcending the boundaries of production and productivity despite the serious constraints of dwindling size of holding, vagaries of weather and climatic variability marked with recurrent incidences of calamities like drought and floods.

An impressive average growth rate of 3.6 per cent per year during the 11th plan was feasible due to application of improved technologies. The per annum growth rate of 3.8 per cent in food grains and 5.31 per cent in pulse production during 11th plan, while an annual growth rate of 7.6 per cent in horticulture during the last decade sound incredible. However, the goals of food security and inclusive growth are challenging, therefore, efforts are to be scaled up for attaining the target of 8 per cent growth GDP during the 12th plan.

The farmers in India have been the crusaders of several revolutions in agriculture. What they need are appropriate technologies and proper skilling. IARI, the premier institute of agricultural research and education in the country has made applauding contributions towards farmers' as well as nation's prosperity through generation and dissemination of cutting-edge technologies for various agro-ecological situations.

I am delighted to learn that the institute has come out with the third edition of its valuable publication entitled, "Technological Options for Enhanced Productivity and Profit". It contains the detailed descriptions in text and pictures about the improved varieties and package of practices of crops; technologies for natural resource management, post-harvest and value addition, and entrepreneurship development; and farm machineries. The previous two editions were popular among the end users particularly the farmers and entrepreneurs. Considering the importance of such publications in providing information and technical support to the end users, the third edition is being published.

I am sure this publication will be of immense use for the farmers; entrepreneurs, extension workers and farm journalists and be able to bridge the information and technological gaps.

January 28, 2014
New Delhi

(SHARAD PAWAR)

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कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
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FOREWORD

The application of science and technology in Indian agriculture has led to a remarkable progress not only in food grains production but also in horticulture, animal husbandry and fisheries. Today, India ranks among the top five countries in agricultural production. We are the leading producers of rice, wheat, pulses, fruits, vegetables, milk, egg and fish, and net exporter of agricultural produce. In spite of these developments, the current agriculture is stressed by the pressures of burgeoning population, climate change and associated risk, dwindling availability of natural resources, labour problems, rising cost of production, market vagaries, changing food consumption pattern, and widening inequality of incomes.

In order to sustain the achievements made in the farming sector there is a need to develop innovative technologies and also transfer the same among farming community. The pivotal role of Indian Agricultural Research Institute in development and transfer of cutting edge technologies for ensuring agricultural prosperity is well known. The Institute has also developed several innovative extension methodologies for transfer of farm technologies across the country. The need of the hour is to enhance the efficiency of extension system to accelerate the diffusion of innovations among the farmers. An effective flow of information and availability of technological support is very much essential.

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

(S. Ayyappan)

January 28, 2014
New Delhi

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PREFACE

The Indian Agricultural Research Institute has successfully served the cause of farmers through generation and transfer of appropriate technologies as well as development of human resources. The new crop varieties, hybrids and other technologies along with their associated management technologies developed by the Institute have brought out an unprecedented increase in agricultural production and productivity. Several initiatives have also been taken to meet the new challenges of climate change, shrinking natural resources, emerging pests and increasing demand for high quality farm produce. The transfer of technology has always received high priority of the Institute as the improved technologies need to be adopted by the farmers to enhance their productivity and income. Keeping this in view, several innovative extension models and strategies have been developed.

I am delighted to learn that the first and second editions of technology bulletin "Technological Options for Enhanced Productivity and Profit" has been a great success in meeting the information needs of farming community and extension professionals. This has necessitated bringing out this third revised edition of this publication to meet the demand of different stakeholders in agricultural development in all parts of the country. This updated publication provides brief and latest 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 stations, 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), Dr. K.V. Prabhu, Joint Director (Research) and their team of scientists in collecting and compiling the information.

I hope, this publication will benefit all concerned and contribute to driving Indian agriculture on a higher path of growth.

(H.S. Gupta)

January 28, 2014
New Delhi

Contents

Introduction

The Indian Agricultural Research Institute, popularly known as Pusa Institute, has been the premier institution for agricultural research, education and extension of the country. During its 108 years of existence, it has attained great heights in various fields of its endeavour.

The Green Revolution that brought smiles to millions of Indians bloomed from the fields of IARI with the development of the famous high yielding wheat varieties. This marked the beginning of a new era in the agricultural research in the country. The Institute has succeeded in developing high yielding, climate resilient crop varieties combining resistance to both biotic and abiotic factors and enhanced nutritional quality in field crops, vegetables, fruits and flowers.

Apart from developing high yielding crop varieties, IARI has also provided national leadership in areas such as crop management technologies, Integrated Pest Management, Integrated Disease Management, pesticide residue analysis, cropping system research, water management technologies, agricultural implements & machineries and issues related to climate change. It also introduced biotechnology for crop improvements in India through its research on genetic mapping, molecular markers, genome sequencing and transgenic development.

The Institute has developed several extension models for transfer of technologies. The recently developed models such as IARI-Post Office Linkage Model, IARI-SAU partnership extension model, IARI-Voluntary Organizations partnership extension model and Model Village Programme have shown promising results. The Institute also disseminates farm information through mass media and Information and Communication Technologies.

Realizing the importance of making available the information on all the technologies developed by IARI in one place, the first edition of "Technological Options for Enhanced Productivity and Profit" was brought out in Hindi in the year 2010 and in English in 2011. The success and usefulness of the above publication can be seen from the fact that the second edition of this publication had to be brought out in the year 2012. Demand from various stakeholders necessitated the publication of this third revised edition, which contains updated details about available technologies of the Institute. 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.

1

Improved Crop Varieties for Higher Productivity

Improved Pusa Basmati 1 (Pusa 1460)

HD-3086 (Pusa Gautami)

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 2012-13, the country recorded a food production of 255.36 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 cereals, 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 are given below :

Cereal Crops

Wheat

During the year 2012-13, wheat was cultivated in an area of 29.65 million hectares in our country with a production of 92.46 million tonnes of grains and a productivity of 3.12 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-3086 (Pusa Gautami)

Year of release : 2013 (CVRC)

Recommended areas : Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur Divisions), U.P. (except Jhansi Division), Parts of J&K (Kathua district), Parts of HP (Una district & Paonta Valley) and Uttrakhand (*Tarai* region)

Production conditions : Timely sown irrigated

Average yield : 5.46 t/ha

Characteristics : Semi dwarf variety (93 cm) which matures in 143 days. Possesses a high level of resistance against leaf and stripe rusts. Also shows high degree of resistance against loose smut and flag smut. Best HMW sub-unit combination for bread making with Glu-1 score, 10/10. It has best grain appearance score, hectolitre weight, higher value of bread loaf volume (cc) and bread quality score. It may find favour with bread making industry.

HD 3059 (Pusa Pachheti)

Year of release : 2012 (CVRC)

Recommended areas : North Western Plain Zone; Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur Divisions), U.P. (except Jhansi Division), Parts of J&K (Kathua district), Parts of HP (Una district & Paonta Valley) and Uttrakhand (*Tarai* region)

Production conditions : Late sown irrigated

Average yield : 4.25 t/ha

Characteristics : An early maturing (121 days), semi-dwarf (93 cm) wheat variety, which possesses high degree of resistance to all the three rusts including stem rust race Ug99 and its variants. It has shown superior quality parameters with high protein content (13.6%), high sedimentation value (52 ml), best Glu-1 Score (10/10) and meeting all the criteria for superior bread and *chapati* making qualities.

HD-3043 (Pusa Chaitanya)

Year of release : 2011 (CVRC)

Recommended areas : Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur Divisions), U.P. (except Jhansi Division), Parts of J&K (Kathua district), Parts of HP (Una district & Paonta Valley) and Uttrakhand (*Tarai* region)

Production conditions : Restricted irrigated condition

Average yield : 4.28 t/ha

Characteristics : A semi-dwarf variety which matures in 143 days. Possesses a high level of resistance against stripe and leaf rusts. It has best HMW sub-units combination for bread making with Glu-1 score, 8/10 and has the higher value of bread loaf volume (cc), bread quality score.

HD 2967 (Pusa Sindhu Ganga)

Year of release : 2011 (CVRC)

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, Delhi)

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, Delhi)

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, Delhi)

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.

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 micronutrient 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 north eastern states

Production conditions : Timely sown irrigated

Average yield : 4.6 t/ha

Characteristics : Suitable for delayed sowing under 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 north eastern 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.

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 (Malavratna)

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 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.

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.

HI 8713 (Pusa Mangal)

Year of release : 2012 (CVRC)

Recommended areas : Central Zone comprising of the States of Madhya Pradesh, Chhatisgarh, Gujarat, Rajasthan (Kota and Udaipur Divisions) and Uttar Pradesh (Bundelkhand region)

Production conditions : Timely sown irrigated

Average yield : 5.23 t/ha

Characteristics : Durum wheat variety rich in nutrients like Beta-carotene (precursor of Vitamin A) and essential micronutrients like iron and zinc. It has high levels of resistance to stem and leaf rust diseases.

Peninsular Zone

HD-3090 (Pusa Amulya)

Year of release : 2013 (CVRC)

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

Production conditions : Late sown irrigated

Average yield : 4.21 t/ha

Characteristics : An early maturing (101 days), semi-dwarf (80 cm) variety. It showed high degree of resistance to leaf and stem rusts under artificial rust epiphytotic conditions. Possesses good quality parameters for most of the quality traits and end-use for bread and *chapati* purposes.

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.

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.

HW 5216 (Pusa Thenmalai)

Year of release : 2012 (CVRC)

Recommended areas : Southern hill zone

Production conditions : Late and very late sown irrigated

Average yield : 3.7 t/ha

Characteristics : The variety HW 5216 has yielded significantly superior over checks viz., HW 2044 and CoW(W) 1 over three years of testing and recorded highest zonal mean grain yield of 4.5 t/ha and recorded overall yield advantage of +11.82% over best check. It has multiple disease resistance.

HW 1098 (Nilgiri Khapli)

Year of release : 2013 (CVRC)

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

Production conditions : For irrigated and timely sown conditions

Average yield : 4.56 t/ha

Characteristics : Conferring very high degree of resistance to black, brown rusts and powdery mildew with better dicoccum quality. It matures in 106 days.

Northern Hills Zone

HI 1563 (Pusa Prachi)

Year of release : 2010 (CVRC)

Recommended areas : Released for NEP Zone

Production conditions : Late sown irrigated

Average yield : 5.0 t/ha

Characteristics : Bread wheat variety suitable for high fertility, irrigated late sown condition of NEP zone. It showed seedling resistance to almost all the pathotypes of the three rusts; and adult plant resistance to virulent rust pathotypes. It has good levels of resistance to leaf blight, powdery mildew and foot rot diseases as well. It is a good quality wheat genotype with good bread, *chapati* and biscuit making quality with good levels of micronutrients like iron, zinc and copper.

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 *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 : 3.1 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 for threshing. It matures in 185 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 2012-13, rice crop was cultivated in an area of 42.41 million hectares in India with a production of 104.40 million tonnes. The productivity of rice is 2.46 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:

Pusa Basmati 1509

Year of release : 2013 (CVRC)
Recommended areas : Punjab and National Capital Region, Delhi
Production conditions : Timely sown irrigated and transplanted
Average yield : 5.0-5.5 t/ha
Characteristics : First early maturing *basmati* rice variety with seed to seed maturity of only 115-120 days. It has moderate resistance to leaf blast and brown spot diseases. It possesses extra-long slender grains (8.19 mm) with very occasional grain chalkiness, very good kernel length after cooking (18.2 mm), desirable ASV (7.0), intermediate amylose content (21.24%) and strong aroma. Considering the advantages such as semi-dwarf stature, non-lodging and non-shattering habit, reduced duration, yield on par and superior grain and cooking quality traits compared to Pusa Basmati 1121.

Pusa 1612

Year of release : 2013 (CVRC)
Recommended areas : Punjab, Haryana, Delhi and J&K
Production conditions : Irrigated and transplanted
Average yield : 5.5-6.0 t/ha
Characteristics : This variety is an improved version of Pusa Sugandh 5 with on par yield, resistance to blast disease and 120 days seed to seed maturity. It possesses leaf blast resistance gene Piz5 and Pi54. In terms of yield, it is significantly superior to Pusa Basmati-1, Taraori Basmati and Pusa Basmati 1121.

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 growing 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 : 6.5-7.0 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 : 5.5 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 combined harvester use 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 chlorpyriphos 20EC @ 2 ml/L or cartap hydrochloride 50 SP @ 2 g/L or Acephate 75 SP @ 2g /L or monocrotophos 36 SL@1.4 litres/ha in 500-600 liters of water broadcast carbofuran 3 g @ 30 kg/ha or cartap hydrochloride 4 g @ 25 kg/ha for stem borer and leaf folder. Spray Buprofezin 25 SC @ 2 ml/L or fenobucarb 50 EC @ 1ml/5L water or 200 ml confidor/ha in 500-600 litres of water for control of brown plant hopper.

Coarse Cereals

During the year 2012-13, the coarse cereal crops were cultivated in an area of 24.64 million hectares with a production of 40.08 million tonnes. The productivity of coarse cereals is only 1.62 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 2012-13, maize was cultivated in an area of 8.71 million hectares in India with a production of 22.23 million tonnes of grains. The productivity of this crop is 2.55 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, Delhi)

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, Delhi)

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 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 carbaryl (85% WP) 2.35 g/litre of water or granules of Carbofuran 3G or Phorate 10G in the whorl leaves of affected plants for control of stem borer. If necessary, apply fipronil granules @ 20 kg/ha followed by irrigation for termite control.

Pearl Millet (*Bajra*)

During the year 2012-13, *bajra* was cultivated in an area of 7.20 million hectares in India with a production of 8.74 million tonnes. The productivity of this crop is 1,214 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 : 2010 (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 Carbaryl (85% WP) 2.35 g/litre of water or chlorpyriphos 20 EC @2.5 ml/L or Triazophos 20 EC @ 2 ml/L for control of hairy caterpillar, brown beetle and grasshopper.

Pulse Crops

During the year 2012-13, pulse crops were cultivated in an area of 23.47 million hectares in India with a production of 18.45 million tonnes. The recorded average yield of pulse crops is only 786 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 2012-13, the area under chickpea cultivation was 8.70 million hectares in India with a production of 8.88 million tonnes and a productivity of 1,021 kilograms per hectare. The improved varieties of chickpea which can increase the productivity are given below:

Northern India

Pusa 2085

Year of release	:	2013 (SVRC, Delhi)
Recommended areas	:	National Capital Region of Delhi
Production conditions	:	Irrigated
Average yield	:	2.0 t/ha
Characteristics	:	It is a large seeded *kabuli* chickpea variety with 100 seed weight of 36 g. It has multiple disease resistance against dry root rot and stunt; moderately resistant to wilt and Botrytis gray mold and tolerant to collar rot. The seeds are beige coloured, uniform, attractive and shining.

Pusa Green 112

Year of release : 2013 (SVRC, Delhi)

Recommended areas : National Capital Region, Delhi

Production conditions : Timely sown irrigated

Average yield : Average yield is 23 q/ha and has a yield potential of 27 q/ha

Characteristics : Pusa Green is a high yielding *desi* green seeded chickpea variety having high resistance to Fusarium wilt and drought. Seeds are dark green, uniform and excellent for cooking and culinary purpose. It will be a boon for marginal farmers as it has multiple stress resistance. Green seeded chickpeas are in great demand in urban areas for culinary and table purposes.

Pusa 5023

Year of release : 2011 (CVRC)

Recommended areas : National Capital Region of Delhi

Production conditions : Irrigated

Average yield : 2.5 t/ha

Characteristics : An extra bold (50 g/100 seed) *kabuli* chickpea variety moderately resistant to wilt.

Pusa 5028

Year of release : 2011 (SVRC, Delhi)

Recommended areas : National Capital Region of Delhi

Production conditions : Irrigated

Average yield : 2.7 t/ha

Characteristics : An extra bold (41 g/100 seed) *desi* chickpea variety moderately resistant to wilt.

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*)

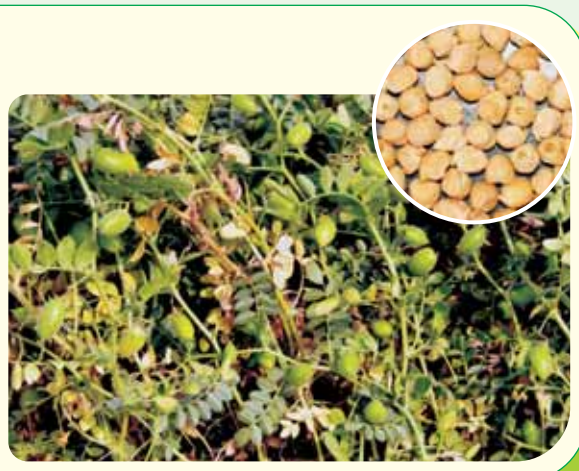
Year of release : 1999 (CVRC)

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, Delhi)

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, Delhi)

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, Delhi)

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, Delhi)

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, Delhi)

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 borne diseases 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 *Ha*NPV @ 250 LE/500 litres of water /ha lambda cyhalothrin 5 EC or indoxacarb 14.5 SC @ 1 ml/2L or monocrotophos (30 SL) @ 250 g a.i. in 500 litres of water/ha for control of pod borer.

Field pea

Pusa Prabhat (DDR 23)

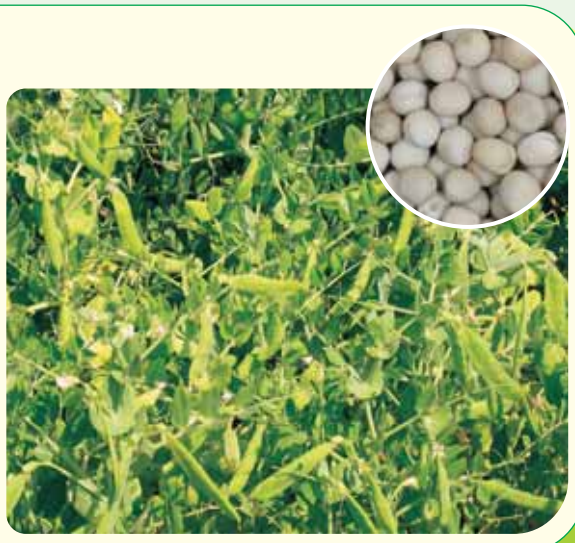
Year of release : 2001 (CVRC)

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 or spinosad 45 SC @ 2 ml/10L 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, Delhi)

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. It is very rich in iron.

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 Thiamethoxam 25 WG @ 2 g/10L or Imidacloprid (17.8%) 20-25 g a.i./ha in 500 litres of water for control of aphids.

Pigeonpea *(Arhar)*

During the year 2012-13, pigeonpea was cultivated in an area of 3.81 million hectares in India with a production of 3.07 million tonnes. The recorded productivity of pigeonpea is only 806 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, Delhi)
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, Delhi)
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, Delhi)
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 or Indoxacarb 14.5 SC @ 1ml/2L for control of pod borer and blister beetle and Spinosad 45 SC @ 1ml/5L or Indoxacarb @ 1 ml/2L 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, Delhi)

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.Seed treatment with imidacloprid 17.8 SL @ 3 ml/kg seed and spray profenophos 50 EC @ 2 ml/L.

Oilseed Crops

During the year 2012-13, the area under major oilseed crops was 26.53 million hectares in India with a production of 31.01 million tonnes and productivity of 1,169 kilograms per hectare.

Mustard

The area under mustard in India during the year 2012-13, was 6.34 million hectares with a production of 7.82 million tonnes. The per hectare productivity of mustard is only 1,234 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, Delhi)
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, Delhi)

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, Delhi)

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% erucic 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, Delhi)

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% erucic 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 30 (LES-43)

Year of release : 2013 (CVRC)

Recommended areas : Uttar Pradesh, Uttrakhand, Madhya Pradesh and easten Rajasthan

Production conditions : Timely sown irrigated

Average yield : 1.82 t/ha

Characteristics : This is the first bold seeded (1000 seed weight 5.38 g) low erucic acid (<2%) variety of Indian mustard which has 37.7% oil content. It matures in 137 days.

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 erucic 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 29 (LET-36)

Year of release : 2013 (CVRC)

Recommended areas : Delhi, Haryana, Jammu, Punjab and northern Rajasthan

Production conditions : Timely sown irrigated

Average yield : 2.17 t/ha

Characteristics : It is a low erucic acid variety (<2%) of Indian mustard. It matures in 143 days. 1000-seed weight of this variety is about 4.0 g with 37.2% oil content.

Pusa Mustard 28 (NPJ-124)

Year of release : 2011 (CVRC)

Recommended areas : Rajasthan, Haryana, Punjab, Delhi, Plains of J&K, HP and Western UP

Production conditions : Early sown (First week of September)

Average yield : 1.99 t/ha

Characteristics : Suitable for multiple cropping system between September *(post-kharif)* to mid-December (upto sowing of *rabi* crops particularly wheat and vegetables) and is a very potential substitute of *B. rapa* cv. Toria (in *toria's* traditional belt). Average maturity 107 days, seeds contain 41.7% oil. It has very high productivity of 18.63 kg/ day/ha.

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 for *toria*. In north eastern and eastern states, it fits well after rice crop. It is a 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)

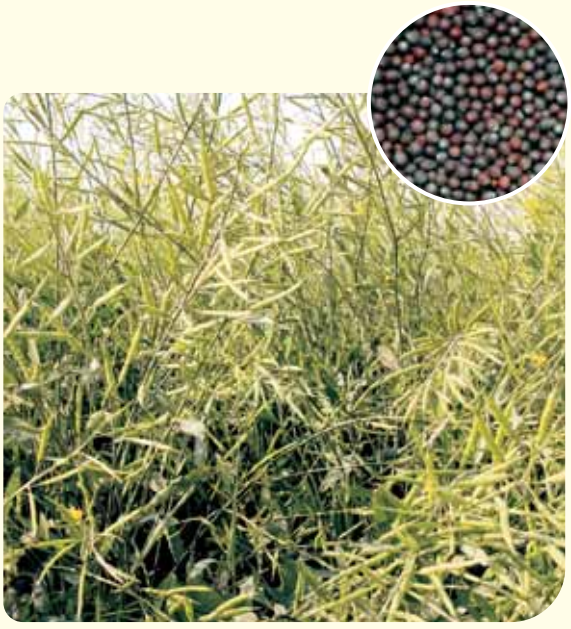
Year of release : 1998 (CVRC)

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 for *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, Delhi)

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, Sclerotia 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.

Northern and North Western Plains Zone

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 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 Carbendazim (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 Mancozeb (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 2012-13, soybean was cultivated in an area of 10.84 million hectares in India with a production of 14.68 million tonnes and a productivity of 1,354 kilograms per hectare. The improved varieties of soybean developed by IARI are given below:

National Capital Region

Pusa Soybean 14 (DS 26-14)

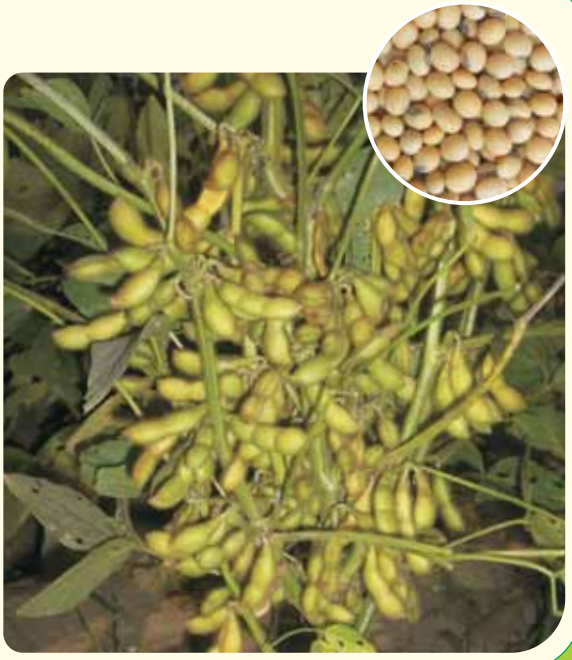
Year of release : 2013 (SVRC, Delhi)

Recommended areas : National Capital Region, Delhi

Production conditions : Late and very late sown irrigated

Average yield : 2.0-3.0 t/ha

Characteristics : The variety has demonstrated significantly higher yield over the best check SL 525 (8.9%). DS 12-13 has resistance against yellow mosaic virus (YMV), Rhizoctonia aerial blight (RAB) and Bacterial Pustule (BP). It is moderately resistant to stem fly, and Defoliators. DS 2614 is a medium-bold seeded variety having 100-seed weight of 9.93 grams. It has good seed longevity and high oil content (20.26%).



Pusa 9712

Year of release : 2005 (SVRC, Delhi)

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 Soybean 12 (DS 12-13)

Year of release : 2013 (CVRC)

Recommended areas : Delhi, Haryana, Punjab, Uttrakhand, U.P. and Bihar

Production conditions : Normal sown irrigated

Average yield : 2.29 t/ha

Characteristics : A bold seeded variety having 100-seed weight of 10.53 grams with good seed longevity and high oil content (19.60%). Possesses resistance against yellow mosaic virus (YMV), rhizoctonia aerial blight (RAB) and Bacterial Pustule (BP). It is having excellent germination and field emergence and hence capable of maintaining proper plant population in the field leading to higher yield.

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: 80-100 kg/ha; **Spacing:** Row to row 45 cm, plant to plant 5 cm; **Depth of sowing:** 3-5 cm; **Time of sowing:** 20th June- 5th July; **Fertilizers (NPK & S, kg/ha):** 25-80-50-20 as basal dose; **Irrigation:** 3-4 irrigations in the absence of rainfall; **Weed control :** Two hand weeding at 21 and 45 DAS or pre-sowing spray of fluchloralin @ 2 L/ha or Imazethapyr @ 75-100 g a.i./ha (15-20 DAS) in 750-800 litres water/ha; **Disease control:** Two sprays of confidor @ 250 g/ha for control of vector of mosaic disease 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 t/ha (green fodder), 20 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 Furadan treated seeds (16-20g Carbofuran 25 ST/100 kg seed) for shoot fly control.

Fibre Crop

Cotton

During the year 2012-13, cotton in India has been cultivated in an area of 11.98 million hectares and its total production was 34.00 million bales (1 bale=170 kgs) with a productivity of 482 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-row, 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 herbicide; **Irrigation**: 3-4 (last irrigation at one-third boll opening); **Seed treatment**: Carbendazim @ 2g/kg seed for seed borne diseases and 10 ml chlorpyriphos 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), triazophos @ 1500 ml/ha (for white fly and pink boll worm), profenophos @ 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.

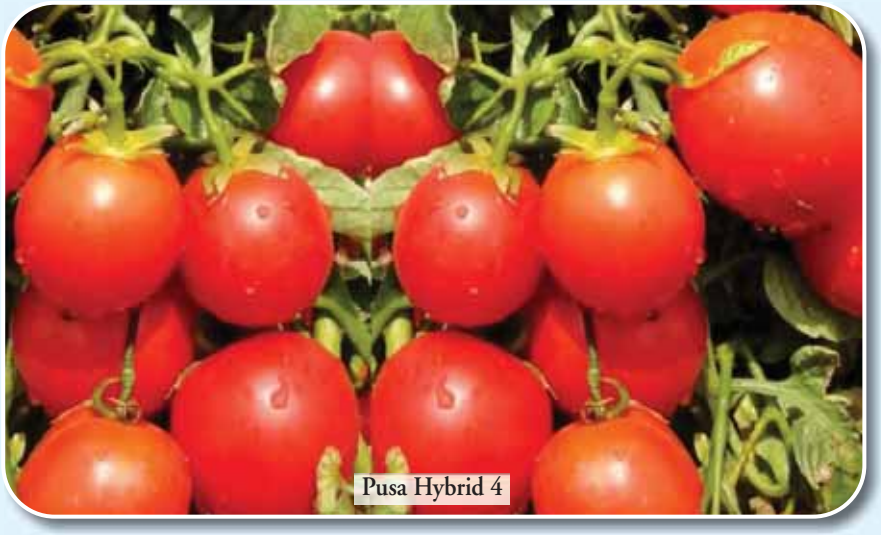
DP 401

Year of release	:	1961 (SVRC, Bihar)
Recommended areas	:	Tobacco growing 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

Pusa Rudhira



Pusa Hybrid 4

Vegetable production scenario in India has made a remarkable progress by producing 162.18 million tonnes from mere 9.2 million hectare area during the year 2012-13. IARI has played a pivotal role through its improved varieties in almost all types of vegetable crops, which have saturated the entire country. With the burgeoning populations' need of balanced diet, the vegetable production needs to be doubled to meet the requirement of Indian population which is expected to surpass 1.3 billion by 2030. This target can be achieved through use of improved vegetable varieties, hybrids and production technologies with the judicious utilization of diminishing land and water resources. IARI has developed many improved varieties and hybrids of vegetable crops, the details of recent and popular one 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.

B. Hybrids

Pusa Hybrid 1

Year of release : 1994 (SVRC, Delhi)
Area of adaptation : Delhi and NCR
Average yield : 30-33 t/ha
Characteristics : Plants determinate. Fruits round, medium, smooth, thick pericarp, ripening even at a night temperature of 28-30 °C. Suitable for long distance transportation.

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.

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 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 Divya

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

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:** 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/Apron SD 35 @ 2 g/kg seed; **Insect control** : For control of fruit borer, spraying of Spinosad (2 ml/10L) or methyl demeton (2 ml/L) and for white flies and jassids, spraying of thiamethoxam (2g/10L) or NSKE (5%).

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 Purple Cluster

Year of release : 1997 (CVRC)
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.

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.

DBL-02

Year of release : 2010 (CVRC)
Area of adaptation : Delhi, Punjab, Haryana
Average yield : 38.2 t/ha
Characteristics : Fruits long, violet-purple with round distal end, each fruit weighing 80-90 g. Maturity 55 days after transplanting.

B. Hybrids

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 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.

DBHL-20

Year of release : 2011 (CVRC)
Area of adaptation : Punjab, Delhi, Uttar Pradesh and Bihar
Average yield : 52.5 t/ha
Characteristics : Fruits long, dark purple, glossy, weighing 90-100 gram and it takes about 55 days from transplanting to first harvest.

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 cypermethrin (1 ml/L) or emamectin benzoate (2g/10L) or spinosad (2 ml/10L) of water in rotation.

Sweet Pepper

A. Improved Varieties

California Wonder

Year of release : 1975 (SVRC, HP)
Area of adaptation : Medium to higher hilly regions
Average yield : 18-20 t/ha
Characteristics : Plant height medium, fruits shining green, 3-4 lobes. First picking 75 days after planting.

B. Hybrids

Pusa Deepti

Year of release : 1997 (SVRC, HP)
Area of adaptation : Temperate and subtropical regions of Northern India
Average yield : 30-35 t/ha
Characteristics : Plant medium, bushy and erect, fruits yellowish green, conical; turns dark red at maturity; first picking 70-75 days after planting.

Chilli

Improved Variety

Pusa Sadabahar

Year of identification : 2013 (IVIC)
Area of adaptation : Throughout India
Average yield : 9.5 t/ha (green) and 1.5-2.0 t/ha (dry)
Characteristics : Plants erect, perennial (2-3 years), 60-80 cm tall; fruits 6-8 cm long, borne in clusters with 6-14 fruits per cluster, ripe fruits dark red, highly pungent, resistant to CMV, TMV and leaf curl complex; first picking in 75-80 days after transplanting.

Paprika

Kt. pl-19

Year of release : 1994 (SVRC, HP)

Area of adaptation : South Indian regions

Average yield : 300-350 kg/ha (for seed); 36-50 t/ha (for fresh fruits); 5.7-7.5 t/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 Apron SD 35 or Thiram @ 2 g/kg seed and for anthracnose, spray Dithane M-45 or Bavistin @ 2 g/litre of water; **Insect control:** Spray metasystox @ (2 ml/L) or imidacloprid (2 ml/10L) for fruit borer and thrips spray emamectin benzoate (2g/10L) or Spinosad (2ml/10L) for control of white flies, aphids and jassids.

Cucurbitaceous Vegetables

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 ^{o}C) as well as high temperature (35-40 ^{o}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.

Pusa Samridhi

Year of release : 2005 (SVRC, Delhi)

Area of adaptation : Delhi & NCR

Average yield : 27-30 t/ha

Characteristics : Fruits long without neck. Maturity in 50-55 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% Karathane or Bavistin for powdery mildew and 0.2% Dithane M-45 or Metalaxyl for downy mildew; **Insect control:** Spray 0.2% carbaryl or DDVP (0.05%) for red pumpkin beetle and malathion 0.1% of water for control of fruit fly.

Cucumber

Improved Varieties

Pusa Uday

Year of release : 2004 (SVRC, Delhi)

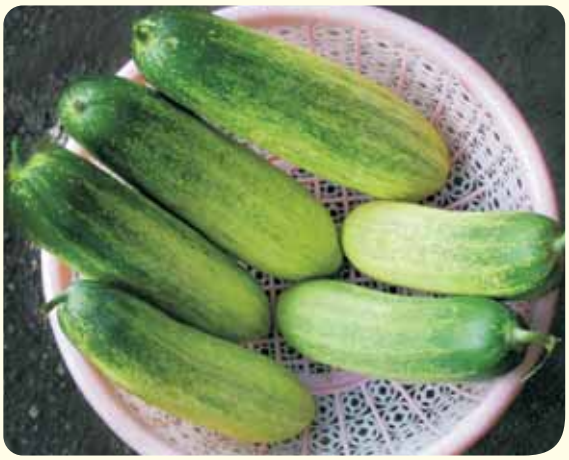
Area of adaptation : Delhi and NCR

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.

Pusa Barkha

Year of release : 2013 (SVRC, Delhi)
Area of adaptation : Delhi and NCR
Average yield : 18.5 t/ha
Characteristics : First extra early improved variety of cucumber for *kharif* season cultivation for north Indian plains. Field tolerant to high humidity, high temperature and downy mildew disease. First harvesting in 40-45 days after sowing.



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:** Spray 0.1% Karathane or Bavistin for powdery mildew and 0.2% Dithane M-45 or Metalaxyl for downy mildew; **Insect control**: Spray 0.2% carbaryl for red pumpkin beetle and malathion 50 EC @ 0.1% 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 or Metalaxyl for downy mildew; **Insect control :** Spray malathion 50 EC @ 1ml/L for the control of fruit fly.

Ridge gourd

Improved Variety

Pusa Nutan

Year of release : 2009 (SVRC, Delhi)

Area of adaptation : Delhi & NCR

Average yield : 16 t/ha

Characteristics : Fruits long (25-30 cm), straight, attractive green, average fruit wt. 105 g, flesh tender, suitable for spring summer and *kharif* season. Maturity in 45-50 days.

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 hoeing and weedings are necessary; **Disease control:** Sprays 0.2% Metalaxyl/Dithane M-45 for downy mildew; **Insect control:** Spray malathion 50 EC @ 1ml/L for the control of fruit fly.

Bitter gourd

A. Improved Varieties

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.

Pusa Aushadhi (Sel-1)

Year of release : 2013 (CVRC)

Area of adaptation : Rajasthan, Gujarat, Haryana and Delhi

Average yield : 19.8 t/ha

Characteristics : Suitable for growing spring-summer in north Indian plains. Fruits are light green, medium long and medium thick (average fruit length 16.5 cm and breadth 6.0 cm) with 7-8 continuous narrow ridges, fruits mature in 48-52 days. Average fruit weight 85 g.

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% Metalaxyl or Dithane M- 45 for downy mildew; **Insect control:** For control of fruit fly spray 5% NSKE as oviposition deterrent to adults. Install trap with Methyl eugenol @ 20 traps/ha. Alternatively spray malathion (2 ml/L) or Spinosad (2 ml/10L). Collect infested and fallen fruits and burn or bury them in deep pits.

Ash Gourd

A. Improved Variety

Pusa Ujwal

Year of release : 2007 (CVRC)
Area of adaptation : Delhi, Punjab and Haryana
Average yield : 45 t/ha
Characteristics : Fruits ellipsoid, ideal for packing and long distance transportation. Maturity in 120 days.

B. Hybrids

Pusa Urmi (DAGH-16)

Year of release : 2013 (CVRC)
Area of adaptation : Rajasthan, Gujarat, Haryana, Delhi, Karnataka, Tamil Nadu and Kerala
Average yield : 47.5 t/ha
Characteristics : Suitable for growing during spring-summer and *kharif* seasons in both north and south Indian plains. Vines are medium long (average length 7.5m) and fruits are oblong ellipsoid with greenish white rind and white flesh. Average fruit weight is 11.0 kg and average number of fruits per plant is 4.60.

Pusa Shreyali (DAGH-14)

Year of release : 2013 (CVRC)
Area of adaptation : Punjab, U.P., Bihar and Jharkhand
Average yield : 52 t/ha
Characteristics : Suitable for growing during spring-summer and *kharif* seasons in north Indian plains. Vines are medium long (7.0m) and fruits are cylindrical with white rind and white flesh. Average fruit weight is 10.5 kg.

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, Delhi)
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, Delhi)

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 or Metalaxyl for downy mildew; **Insect control:** Spray carbaryl @ 2 g/L for control of red pumpkin beetle and malathion 50 EC @ 1ml/L for control of fruit fly.

Summer Squash

A. Improved Variety

Australian Green

Year of release : Exotic introduction

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.

B. Hybrid

Pusa Alankar

Year of release : 1972 (SVRC, HP)

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.

Cole Crops

Cauliflower

A. Improved Varieties

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 ^{o}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 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 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 ^{O}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 Shukti

Year of release : 2009 (SVRC, Delhi)

Area of adaptation : Delhi and NCR

Average yield : 40-44 t/ha

Characteristics : Mid-late (December - January) maturity group (temperature 15-20 ^{O}C), curd compact white. Maturity in 75-80 days after transplanting.

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 Snowball Kt. 25

Year of release : 2004 (CVRC)

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. Resistant to black rot.

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

Improved Variety

Pusa Broccoli KTS-1

Year of release : 1996 (SVRC, HP)
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 transplanting.

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 Apron SD 35 or Thiram @ 2 g/kg seed and for anthracnose; spray Dithane M-45 or Bavistin @ 2 g/litre of water; **Insect control:** Spray Spinosad (2 ml/10L) or chlorantraniliprole (1 ml/10 litres of water) for control of semi looper, caterpillar, diamond back moth and thiamethoxam (2 g /10 litres of water) or deltamethrin (1 ml/ litre of water) @ 10-15 days interval for control of sucking pests.

Cabbage

A. 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 : 1970 (CVRC)
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 (SVRC, HP)
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.

B. Hybrid

Pusa Cabbage Hybrid 1

Year of identification : 2012 (IVIC)

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 Apron SD 35 or Thiram @ 2 g/kg seed and spray Dithane M-45 or Bavistin @ 2 g/litre of water for anthracnose; **Insect control:** Spray Spinosad (2ml/10L) or chlorantraniliprole (1 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

A. Improved Variety

Pusa Virat

Year of release : 2008 (SVRC, HP)

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

A. Improved Variety

Hilds Ideal

Year of release : Exotic introduction

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 in 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.

Brown Spanish

Year of release : Exotic introduction

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 in 160-180 days after planting.

Selection 126

Year of release : 2011 (CVRC)

Area of adaptation : Zone III (Delhi, UP, Haryana, Bihar, Punjab), Zone IV (Rajasthan, Gujarat), Zone V (MP, Chattishgarh and Orissa)

Average yield : 25 t/ha

Characteristics : Bulbs are compact, flat globe, and brownish in colour with high TSS 17 ± 2^{O} Brix. Single bulb weight ranges from 70 – 100 g. Suitable for storage, drying, processing and export.

Pusa Riddhi

Year of release : 2013 (SVRC, Delhi)

Area of adaptation : Delhi and NCR

Average yield : 31 t/ha

Characteristics : Bulbs of this variety are compact, flat globe, and dark red in colour. Average equatorial diameter of bulbs ranges from 4.5 – 6.0 cm, polar diameter ranges from 4.8-6.3 cm and single bulb weight ranges from 70 – 100 g. It is pungent and rich in antioxidant (quercetin 107.42 mg/100g). The variety is suitable for *kharif* and *rabi* season. The variety is also suitable for storage and export.

Bunching Onion

A. Improved Variety

Pusa Soumya

Year of release	:	2013 (SVRC, Delhi)
Area of adaptation	:	Delhi and NCR
Average yield	:	25 t/ha from single harvest
Characteristics	:	First bunching onion variety proposed for commercial cultivation in India. This is a multi-cut variety and suitable for round the year green onion production. It produces bluish green leaves and clumps can be separated for further multiplication.

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 Stemphyllium blight and purple blotch diseases, spray Dithane M -45 @ 0.25% after mixing Sendovit @ 1ml/litre of water; **Insect control:** Spray malathion 50% EC @ 2 ml/litre or dimethoate (2 ml/L) or lambda cyhalothrin (5 ml/10L) of water for control of thrips.

Root Crops

Carrot

A. Improved Varieties

Pusa Vrishti

Year of release	:	2009 (SVRC, Delhi)
Area of adaptation	:	Delhi and NCR
Average yield	:	20-22 t/ha
Characteristics	:	A heat tolerant tropical carrot variety. It is suitable for early sowing beginning in July under north Indian plains. Roots are triangular in shape and self red coloured. Average root weight is 150-200 g. Maturity in 90 days.

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 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.

Pusa Yamdagni

Year of release : 1988 (CVRC)
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 in 90-100 days after sowing.

B. Hybrids

Pusa Vasuda

Year of release : 2013 (SVRC, Delhi)
Area of adaptation : Delhi and NCR
Average yield : 40 t/ha
Characteristics : First public sector tropical carrot hybrid developed using CMS system. Roots are smooth, attractive, vigorous, self-coloured, red, sweet, juicy, rich in total carotenoids, lycopene, TSS and minerals. Suitable for salad, juice extraction, cooking and industry for carotenoid extraction. Maturity in 80-90 days.

Pusa Nayanjyoti

Year of release : 2009 (SVRC, HP)
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.

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.

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).

Pusa Jamuni

Year of release : 2013 (SVRC, Delhi)
Area of adaptation : Delhi & NCR
Average yield : 50 t/ha
Characteristics : First purple fleshed unique trait nutritionally rich radish variety. Distinct advantage in root size, shape, yield and consumer preference over the existing varieties. Higher anthocyanins (8.04 mg/100 g) and ascorbic acid (44.8 mg/100 g). Maturity in 55-60 days.

Pusa Gulabi

Year of release : 2013 (SVRC, Delhi)
Area of adaptation : Delhi and NCR
Average yield : 60 t/ha
Characteristics : First entire pink fleshed unique trait nutritional rich radish variety. Medium root size, cylindrical shape, optimal yield and consumer preference over the existing varieties. High total carotenoids (15.6 mg/100 g), anthocyanins (4.41 mg/100 g) and optimal ascorbic acid (39.2 mg/100 g). Maturity in 55-60 days.

Pusa Vidhu

Year of identification : 2013 (IVIC)
Area of adaptation : Delhi and NCR
Average yield : 40-45 t/ha
Characteristics : The roots are medium, extra white, cylindrical. Maturity in 50-55 days.

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 EC @ 2.0 ml/litre or dimethoate (2 ml/L) of water for control of aphids.

Turnip

Improved Varieties

Purple Top White Globe

Year of release : 1975 (CVRC)

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 in 55-60 days.

Pusa Chandrima

Year of release : 1970 (SVRC, HP)

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. Maturity in 55-60 days.

Pusa Swarnima

Year of release : 1970 (SVRC, HP)

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.

Pod Vegetables

Garden pea

Improved Varieties

Pusa Shree

Year of identification : 2013 (IVIC)

Area of adaptation : Suitable for early sowing in north Indian plans

Average yield : 5.0-5.2 t/ha

Characteristics : Extra early fusarium wilt resistant variety suitable for sowing during late September to early October in north Indian plains. Pods dark green with 6-7 seeds/pod. Pods get ready for harvesting in 50-55 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 deltamethrin (2.5 EC) @ 1 ml/ litre of water for control of pod borer.

Broad Bean

Improved Variety

Pusa Udit

Year of release : 2013 (SVRC, Delhi)
Area of adaptation : Delhi and NCR
Average yield : 17.5 t/ha
Characteristics : Pods extra long, flattish and light green. Fresh seeds are attractive green, good in taste. This is a dual purpose broad bean variety. Both tender pods and dried seeds are edible.

Cowpea

Improved Variety

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 malathion 50 EC @ 2 ml/litre of water for control of leaf miner.

Leafy Vegetables

Vegetable mustard

Improved Variety

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 or metasystox (2 ml/L) of water for control of aphids.

Amaranth

Improved Varieties

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.

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 15 t/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:** Spray imidacloprid (2 ml/10L) or dimethoate (2 ml/L) for leafhoppers and whiteflies. Use cypermethrin (1 ml/L) or Spinosad (2 ml/10L) or emamectin benzoate (2 g/10L) for shoot and fruit borer. Alternatively spray mixture of triazophos and deltamethrin (1 ml/L) both for sucking insects and fruit borer.

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 / Broadbean
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

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 Mridula	1st fortnight of Sept. to Mid-November	2nd fortnight of October to 1st fortnight of January
Pusa Vidhu	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

Pusa Mridula

Year round carrot production in North-Indian plains

Carrot varieties can be grown throughout the year as per table below:

S.No.	Varieties	Sowing time	Availability	Yield (t/ha)
1.	Pusa Vrishti	July	October-November	18-20
2.	Pusa Meghali	August	November-December	22
3.	Pusa Rudhira, Pusa Asita	September-October	December-January	30-35
4.	Pusa Yamdagni, Pusa Nayanjyoti	September-November	December-February	27-32
5.	Pusa Yamdagni, Pusa Nayanjyoti	December-February	March-May	20-25
6.	Pusa Yamdagni, Pusa Nayanjyoti, Pusa Vrishti	March-April	June-July	13-15

Pusa Rudhira

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 - early June	22-27 °C	End of September -October
Early I(b)	Pusa Deepali	Mid June onward	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 Kt.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 Bindu Pusa Ankur Pusa Hybrid 5 Pusa Hybrid 9	June-July	400-500 g	4-5
2.	Tomato	Pusa 120 Pusa Rohini Pusa Sheetal Pusa Hybrid 2 Pusa Hybrid 4 Pusa Hybrid 8 Pusa Hybrid 1 Pusa Sadabahar	October-November January-February	400-500 g	3-4
3.	Chilli	Pusa Sadabahar	June-July	800-1000 g	4-5
4.	Sweet pepper	California Wonder Pusa Deepti	October-November	1.0-1.5 kg	4-5
5.	Cauli-flower	Pusa Meghna Pusa Deepali Pusa Sharad Pusa Paushja Pusa Shukti Pusa Snow Ball K-1 Pusa Snow Ball Kt. 25	May-June June July-August August-September September-October	600-700 g 500-600 g 400-500 g 300-400 g	4-5 3-4 3-4 3
6.	Cabbage	Golden Acre Pusa Drum Head Pusa Mukta	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 Pusa Virat	September-November	1-1.2 kg	5-6
8.	Broccoli	Pusa Broccoli Kt.S. 1	September-November	400 g	4-5
9.	Brussels Sprouts	Hilds Ideal	September-November	375-400 g	4-5
10.	Chinese Cabbage	Palampur Green	October-November	400-500 g	4-5
11.	Onion	Pusa Red Pusa Madhvi N-53 and Agrifound Dark Red	Main crop : October-November *Kharif* crop : Late May-June	8-10 kg 10-12 kg	6-7 5
12.	Leek	Palam Poushtik	March-July	8-10 kg	6-7
13.	Lettuce	Great Lakes	September-October	500 g	4-5
14.	Celery	Ford Hook Emperor Exotic varieties	September-October	150-200 g	8-10
15.	Parsley	Moss Curled	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 during winter season

Low cost polyhouse

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 captafol @ 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.

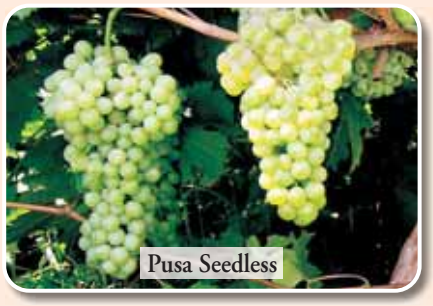
Economics and Technological details

One polyhouse (Size 5 m x 10 m = 50 m^2) cost and material:

• PVC Pipe ½" size – 350 ft. @ ₹ 11/- per ft.			:	₹ 3,850/-
• PVC Pipe 1" size – 120 ft. @ ₹ 18/- per ft.			:	₹ 2,160/-
• Polythene 700 gauge – 64 meter @ ₹ 37.80 per meter			:	₹ 2,420/-
• Rope/Plastic			:	₹ 50/-
• Five labour for making polyhouse 5 x 200			:	₹ 1,000/-
• Miscellaneous			:	₹ 1,000/-
Total			:	₹ 10,500/-
Poly bags:	250 bags/m^2			
• Cucumber Seedlings	Ground	40m^2	:	10,000
	1st story	30m^2	:	7,500
	Total		:	17,500 plants/50 m^2
• Seedlings @ ₹ 2/- (17,500 x 2)			:	₹ 35,000/- per 50 m^2
@ ₹ 1.5/- (17,500 x 1.5)			:	₹ 26,250/- per 50 m^2
	Investment		:	₹ 10,500/-
	Profit @ ₹ 2/-		:	₹ 24,500/-
	Profit @ ₹ 1.5/-		:	₹ 15,750/-
Pro-tray:				
0.60 x 0.30 = 0.16 m^2			:	50 seedlings
7,500 plants/40 m^2				
12,000 plants/40 m^2 ground (240 trays)			:	12,000 plants/40 m^2
9,000 plants/30 m^2 1st storey			:	9,000 plants/30m^2
Total plants			:	21,000 plants
@ ₹ 2.0/- per plant			:	₹ 42,000/-
@ ₹ 1.5/- per plant			:	₹ 31,500/-
Total cost: 10,500 + trays cost ₹ 6,000/-			:	₹ 16,500/-
Net Profit			:	₹ 25,500/- @ ₹2/Seedling
			:	₹15,000/- @ ₹1.5/Seedling

3

Improved Fruit Varieties and Production Technologies


Pusa Seedless


Pusa Amrapali

The area under fruit crops during the year 2012-13, was 6.98 million hectares with a production of 81.28 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 : 2012 (SVRC, Delhi)
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 β-carotene content (10,964 µg/100 g pulp). It has pleasant flavour with improved shelf life (7 to 8 days) at room temperature. It is suitable for domestic market as well as international market.

Pusa Pratibha

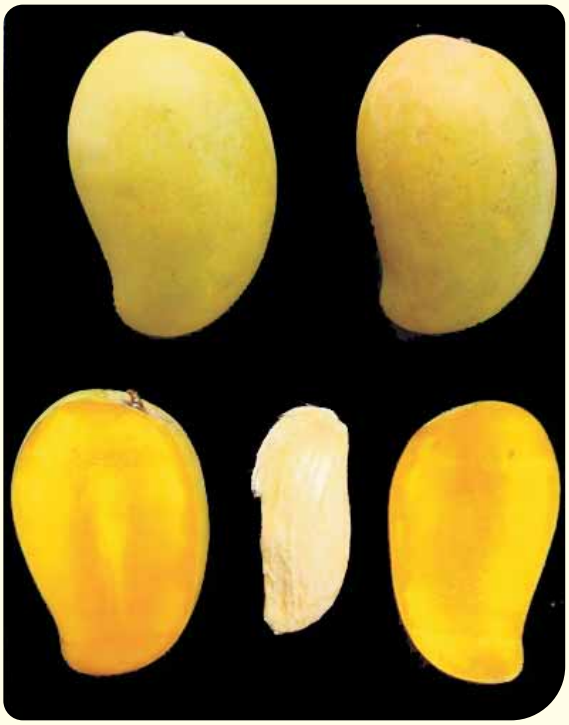
Parentage : Amrapali x Sensation
Year of release : 2011 (SVRC, Delhi)
Recommended region : Plains of North and Central India with probability in Penninsular India
Average yield : 40-42 kg per tree
Characteristics : Regular bearer, semi-vigorous and suitable for closer planting (6 m x 6 m). Fruits are 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 β-carotene content (11,474 µg/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 (SVRC, Delhi)
Recommended : Plains of North and Central India
Average yield : 50-60 kg per tree
Characteristics : Regular bearer, semi-vigorous and 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 β-carotene content (13,028 µg/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 (SVRC, Delhi)
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 and 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 β-carotene content (11,737 µg/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) and 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 (SVRC, Delhi)

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 ^{O}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 (SVRC, Delhi)

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 ^{O}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, an 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 (SVRC, Delhi)

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 (SVRC, Delhi)

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 (SVRC, Delhi)

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 °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 Malathion dust in rainy season for control of chaffer beetle.

Lemon

Kagzi Kalan

Parentage : It is a lemon selection

Year of release : 1990 (SVRC, Delhi)

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°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 °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 size is medium to large and 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 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.

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 with male and female plants. 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.

Papaya Cultivation

Nursery Raising

Summer Nursery

Prepare a flat and finely pulverized seedbed of 1m x1m by digging soil 6 inch deep and removing all weeds, roots and stubbles. Add 5 kg sand, 20 kg compost and 1 kg *neem* cake thoroughly with soil and make plain seedbed. Sow the healthy seeds with 2-3 inch row to row, 1" plant to plant distance and ½ inch depth. Cover the seeds after sowing. Make small bund around seedbed to facilitate irrigation. Irrigate the seedbed after sowing. Plants will germinate in 15- 20 days. Give further irrigations at 2-3 days interval and remove the weeds gently by hand. Prepare polythene bags by filling a mixture of 1 part soil, 1 part compost and 1 part sand. After six days of germination transfer the plants to polythene bags. Keep the plants for 10-15 days in polythene bags, irrigate the plants daily by hand sprinkle and then transplant healthy plants in the field in pits.

Kharif nursery

Three to four inch raised seedbed, sloping outwardly without bunds is prepared to avoid water logging. Other things remain the same as in summer nursery.

Preparing pits

Dig 2 x 2 feet pits of 2½ feet depth at a distance of 1.5 m x 1.5 m. Expose pits for sun sterilization for 10-12 days. Mix 15 kg compost, 20 g chlorpyriphos, 500 g *neem* cake, 50 g Urea, 100 g IFFCO (12:32:16) fertilizer and rest soil (healthy) thoroughly and fill the pits so that the bed remains slightly raised from soil. Transplant papaya seedling from polythene bags after 10-15 days in these pits.

Transplanting seedlings

Three healthy papaya seedlings from polythene bags are transplanted to each pit in a triangle, maintaining one feet plant to plant distance. Probability of male plants is 50%. Out of 50 plants at least 10 male plants are kept for proper fertilization. The better male plants are grown and others removed subsequently. Only one plant per pit is kept finally.

Fertilizer application

A mixture of 90 g urea, 250 g single super phosphate and 110 g muriate of potash is applied around the plant in a circular ring along the shade of plant canopy at 2month interval for 6 times.

Irrigation

Prepare bunds around the plants and give adequate/requisite irrigation at 15 days intervals.

Yield

On an average every plant yields 35-50 fruits, each weighing 800 g to 1.5 kg approximately. When fruits start yellowing they are plucked, wrapped in paper and kept for 2-3 days for complete ripening.

Care

Diseased plants should be replaced with healthy plants at regular intervals. Plants require frequent weeding and earthing particularly in rainy season. Make arrangements to save plants from strong winds, water logging and pests.

Female

Male

High Density Planting Technique

Keeping in view the shrinking holding sizes and other management problems, the Institute, 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 ha 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.

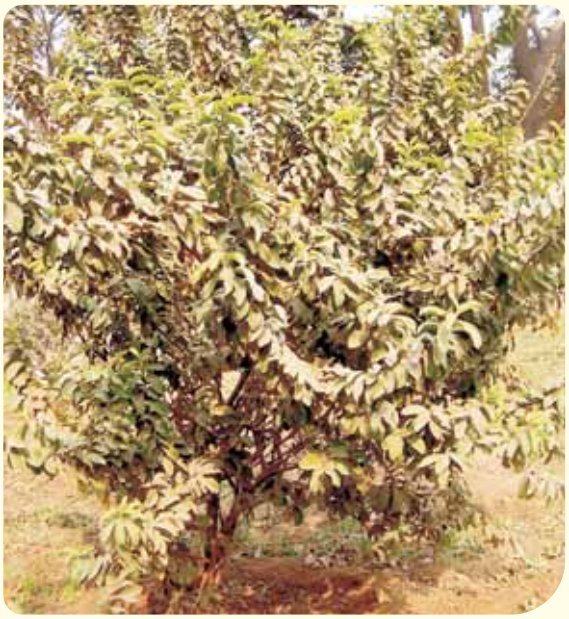
Guava

Pusa Srijan

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

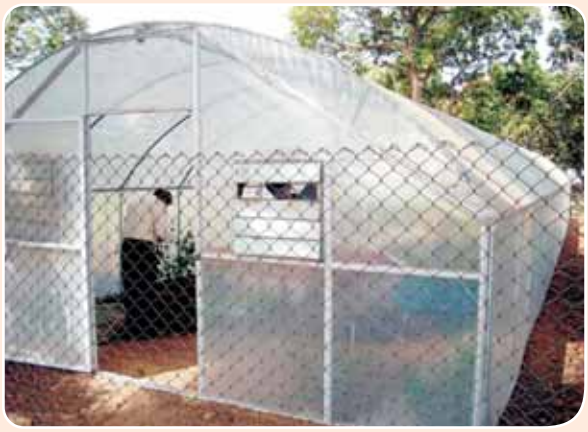
Year of release : 2004 (Delhi State Variety Release Committee)

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.



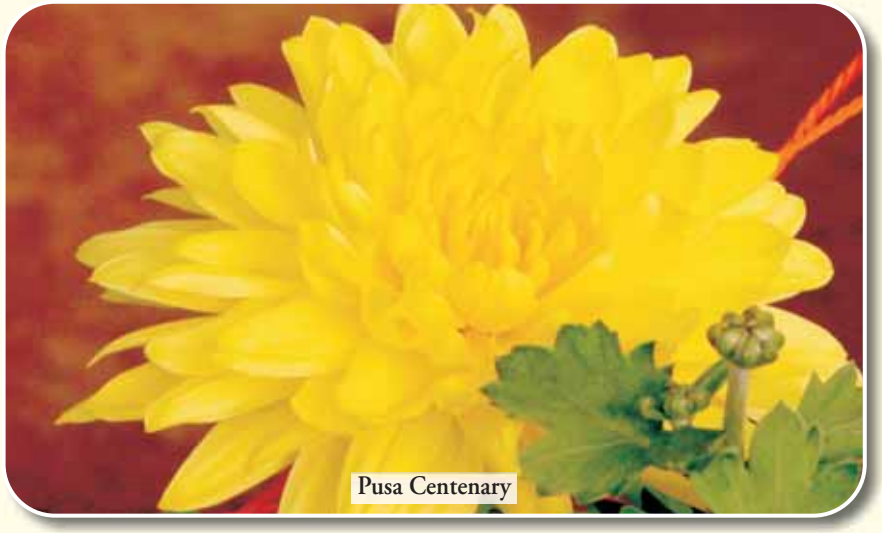
Intercropping in Fruit Orchards

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

Pusa Priya



Pusa Centenary

Floriculture as a commercial activity is still largely practiced on small farms all over India. Flower crops are cultivated in an estimated area of 2,24,000 hectares and this large area generates a total production of 1.46 million tonnes of loose flowers and 87,499 lakh cut flowers (2012-13). 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 flower crops developed by the Institute is as below:

Rose

Pusa Arun

Parentage : Queen Elizabeth x Jantar Mantar

Year of identification : 2005 (IVIC)

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 identification : 2005 (IVIC)

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 are mildly fragrant and are suitable for cut flower industry as well as exhibition purposes.

Pusa Ajay

Parentage : Pink Parfait x Queen Elizabeth
Year of identification : 2005 (IVIC)
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 as well as exhibition purposes.

Pusa Komal

Parentage : Pink Parfait x Suchitra
Year of identification : 2005 (IVIC)
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 and tolerant to black spot.

Recommended cultivation practices

Spacing: 50-60 cm.; **Budding:** February–March; **Planting time:** 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 identification : 1995 (IVIC)

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 identification : 1995 (IVIC)

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 : 2012 (SVRC, Delhi)

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 mite.

Gladiolus

Pusa Shubham

Parentage : Lucky Shamrock x Green Lilac Open

Year of release : 2012 (SVRC, Delhi)

Recommended area : Northern plains

Average yield : Produces 1.6-2.3 shoots and more than 2 corms and 20 cormlets 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 : 2012 (SVRC, Delhi)

Recommended area : Northern plains

Average yield : Produces 1.9-2.7 shoots and more than 2 corms and 20 cormlets 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.

Pusa Manmohak

Parentage : A selection from Mayur x Hunting Song

Year of release : 2013 (SVRC, Delhi)

Recommended area : Northern Plains

Average yield : Produces 2.22 spikes and 2.33 corms

Characteristics : A mid-maturing variety flowering in about 100-105 days. The florets are saffron red (40B) with thin whitish stripes on the throat of two oppositely placed lower petals. Spikes are more than 93 cm in length with good rachis length (55 cm) and about 19-21 number of florets per spike. About 5-6 florets remain open at a time which makes it excellent for vase decoration with vase life of 10 days.

Pusa Vidushi

Parentage : A selection among the progeny obtained from the cross of Melody x Berlew

Year of release : 2013 (SVRC, Delhi)

Recommended area : Northern Plains

Average yield : Produces 2.11 spikes and 2.33 corms

Characteristics : The plants are healthy, light green in colour and straight. An early and mid-maturing variety, first floret opens 80-85 days after planting. Spikes are straight with good rachis length and about 15-16 number of florets per spike. Florets are purplish white in colour with greyed purple spots on the base of the throat. Compact arrangement of florets on one side of the spike coupled with 5-6 florets remaining open at a time with vaselife of 11 days.

Pusa Red Valentine

Parentage : A selection among the open pollinated population of the variety 'Regency'

Year of release : 2013 (SVRC, Delhi)

Recommended area : Northern Plains

Average yield : Produces 2.11 spikes and 2.33 corms

Characteristics : Plants are healthy, green in colour and straight reaching a height of 125cm. Each corm produces on an average two shoots with 7-8 leaves. A mid maturing variety flowering in about 95 days. Spikes are straight and long with good rachis length (50-55 cm) and close arrangement of 18-19 florets on spike. Florets are brick or blood red (53B) in colour with sun ray like small lines on the lower tepals which makes them more attractive and have 10 days vaselife. This variety produces on an average 2.33 corms and more than 28 cormlets from each mother corms.

Pusa Srijana

Parentage : A selection among the progeny obtained from the cross between Berlew and Heady Wine

Year of identification : 2013 (IVIC)

Recommended area : Northern Plains

Average yield : Produces 2.11 spikes and 2.33 corms

Characteristics : Produces spikes of more than 115 cm and florets ranges from 16-20 in number on very long strong/sturdy spikes which last for more than 9 days in vase. It has rachis length > 56 cm. It is very good multiplier producing 2.88 corms and 49.78 cormlets from each mother corm. This is medium to late flowering hybrid and takes 107 days to first floret opening after planting. Floret colour is red purple group (72B) (inner two tepals are dark/ pink with one white stripe on centre and outer tepals are light white at base) with a vaselife of 7 days.

Pusa Unnati

Parentage : A selection among the progeny obtained from the cross between Berlew and Heady Wine

Year of identification : 2013 (IVIC)

Recommended area : Northern Plains

Average yield : Produces 2.11 spikes and 2.33 corms

Characteristics : Produces spikes of more than 85 cm and florets ranges from 15-17 in number on medium long sturdy spikes which last for more than 9 days in vase. It has rachis length > 49 cm. It is very good multiplier producing 3.10 corms and 27.44 cormlets from each mother corm. This is also an early flowering hybrid and takes 73.22 days to first floret opening after planting. Dark pink/mauve floret colour is very attractive (purple group, N-78B) . Highly suitable for garden display/kitchen garden and landscaping also.

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 Thimet 10 G granules @ 20-25 kg/ha in soil at land preparation to control chaffer beetle and 0.2% spray of 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 : 2012 (SVRC, Delhi)

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 : 2012 (SVRC, Delhi)

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.

Pusa Aditya

Parentage : A seedling of cv. Jaya

Year of release : 2013 (SVRC, Delhi)

Recommended area : Northern Plains

Average yield : 300-400 flowers /plant (Spray type)

Characteristics : The Plants are bushy (30-35 branches) and medium in height (55-60 cm) with moderate spread (45-50 cm). The variety is a spray type that produces star shaped semi-double flowers that resemble to gazania flowers. The flowers are yellow in colour (5 A) at the periphery with orange red colour (45A) in the centre. The florets are spatulate with distinct keel. This attractive variety is suitable for garden display.

Pusa Chitraksha

Parentage : A seedling of cv. Lal Pari

Year of release : 2013 (SVRC, Delhi)

Recommended area : Northern Plains

Average yield : 400-500 flowers/ plant (Spray type)

Characteristics : The Plants are bushy (24-30 branches), tall in height (60-65 cm) with excellent spread (60-65 cm). The variety is a spray type that produces single flowers that are deep magenta in colour. The florets are spatulate in shape with magenta colour (59A) at the periphery with silvery white ray floret tube. The disc florets are yellow (12A) that provide a very good contrast. Owing to its floriferous nature, the variety is suitable as a potted plant and for garden display.

Pusa Sona

Parentage : A seedling of cv. Sadbhawana
Year of release : 2013 (SVRC, Delhi)
Recommended area : Northern Plains
Average yield : 200-300 flowers plant (Spray type)
Characteristics : The Plants are bushy (20-25 branches), dwarf in height (25-30 cm) with an excellent spread (50-55 cm). Spray type variety produces single flowers that are yellow in colour (8A). The disc florets are also yellow (12C). The variety is early flowering by atleast 20 days in advance as compared to other varieties. The variety is ideally suited for pot mums.

Pusa Kesari

Parentage : An induced mutant of Thai Chen Queen
Year of release : 2013 (SVRC, Delhi)
Recommended area : Northern Plains
Average yield : 30 flowers/m^2
Characteristics : It is a gamma ray induced red coloured mutant of cv. Thai Chen Queen, which is orange in colour. Red coloured ray florets (171A) appeared as chimers which were used for *in vitro* regeneration to establish as a new variety. The plants are tall in height (65-70 cm) with good spread (60-65 cm). The semi double flowers are big (9-10 cm diameter). The variety is suitable as a cutflower and pot culture.

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Parentage : An induced mutant of Thai Chen Queen
Year of release : 2013 (SVRC, Delhi)
Recommended area : Northern Plains
Average yield : 30 flowers/m^2
Characteristics : It is a gamma ray induced pink coloured mutant of cv. Thai Chen Queen, which is orange in colour. Pink coloured ray florets (65D) appeared as chimeras which were used for *in vitro* regeneration to establish as a new variety. The plants are medium in height (50-55 cm) with good spread (60-65 cm). The semi double flowers are big (7-8 cm diameter). The variety is suitable as a cut flower and pot culture.

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 Rogor (30%) @ 2 ml/litre of water.

Dry Flower Technology

Chrysanthemum drying: Drying technology has been standardized for chrysanthemum varieties like Vasantika, Gauri, Maghi White and Jayanti. Freshly harvested flowers are embedded in silica gel and then are dried in hot air oven at 45 °C for 48 hours which was ideal for Vasantika, Gauri and Jayanti, and for cv. Maghi White, drying in microwave oven for 90 second was promising.

Annual chrysanthemum: Annual chrysanthemum (*Chrysanthemum coronarium*) is gaining popularity in recent times in northern India. It is the second most important loose flower crops grown after marigold. The Division has a strong research programme on annual chrysanthemum with a number of promising lines in pipeline for release. In order to add value to the varieties released by the Institute for enhancing the earnings, the division has also standardized the drying techniques for the white and yellow cultivars by embedding them in silica gel and drying at 40 °C for 48 hrs. in hot air oven for retaining the floral morphology and colour which can be used further for making value added products.

Crop-specific drying technologies for annual flowers

Crop	Technology
Calendula	Press-drying of flowers in microwave oven for 90 seconds
Marigold	Press-drying of flowers in microwave oven for 120 seconds
Larkspur	Press-drying at 40 °C in hot air oven for 24 hours
Pansy	Press-drying of flowers in microwave oven for 100 seconds
Poppy	Press-drying of flowers in microwave oven for 90 seconds

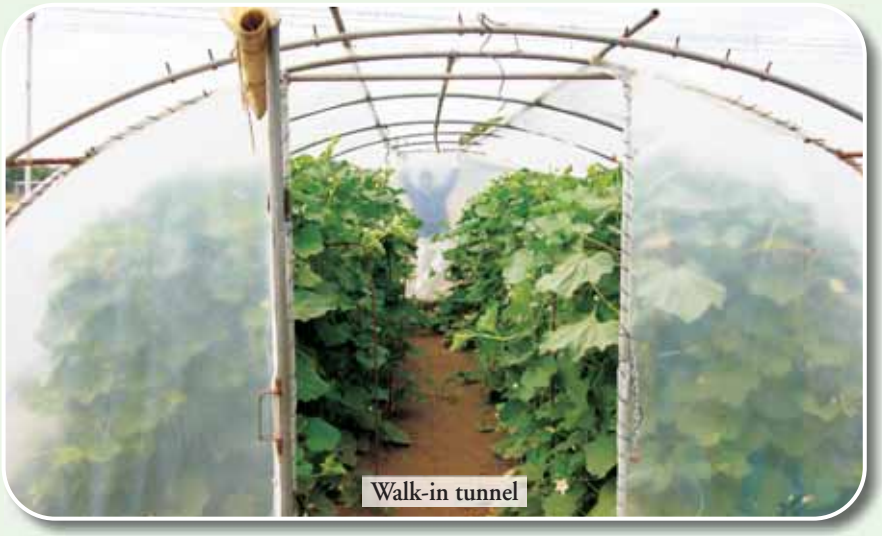
State of the art laboratory for value addition at Division of Floriculture and Landscaping

Note: 45A, 5A etc. refers to Royal Horticultural Society (RHS) colour coding chart.

5

Agricultural Technologies for Higher Income and Employment

Pusa fruit drinks



Walk-in tunnel

Protected Cultivation

Protected cultivation is a cropping technique for growing horticultural crops under protective structures to shield them from pests and weather for assured, climate-resilient and enhanced production of quality products. Protected cultivation can be undertaken in the following structures:

Naturally ventilated polyhouse technology

This is a special structure made of G.I. pipes, insect proof nets and transparent plastic sheets, which protect the crops from adverse climatic conditions, insect-pests and different viruses. In this type of polyhouse all four sides of the greenhouse are covered with an insect-proof, 40 mesh nylon net. Rollable plastic curtains from the ground are used to cover sides. During summer, this plastic curtain is rolled up and down in winter for proper cross ventilation with the help of a pipe. The roof is covered with 200 micron thick, transparent polythene film. An insect-proof nylon net is also used in place of roof ventilators for natural air flow and insect free ventilation. This kind of polyhouse does not require electricity. For irrigation, low pressure drip irrigation system is used. This type of structure is suitable for peri-urban areas where high value vegetables like tomato, capsicum, parthenocarpic cucumber etc. and flowers like rose, chrysanthemum and gerbera can be grown easily.

Optimum size and cost of construction of polyhouse

Optimum size	:	1000 m^2
Expected cost of fabrication	:	₹ 10-12 lakhs
Design of structure	:	Saw-tooth or multi-span
Irrigation system	:	Drum kit or low pressure drip system

Naturally ventilated polyhouse

Economics of vegetable cultivation in naturally ventilated polyhouse (per 1000 m^2 area)

Main components	Tomato	Capsicum	Parthenocarpic cucumber
Crop duration	August-May	August-May	Mid July-May (3 crops)*
Suitable varieties	GS-600	Swarna, Indra, Orobelle, Bombi	Kian, Isatis
First harvesting of fruits	October	October	30-35 days after transplanting
Expected yield	15 tonnes	6-7 tonnes	12 tonnes
Total cost of crop production	₹ 90,000/-	₹ 2,00,000/-	₹ 1,20,000/-
Expected gross income (₹15 x 15,000 kg)	₹ 2,25,000/-	₹ 3,50,000/-	₹ 2,40,000/-
Expected net return (₹)	₹ 1,35,000/-	₹ 1,50,000/-	₹ 1,20,000/-
Cost-benefit ratio	1:2.50	1:2.56	1:2.0

** First crop: July-October, Second crop: Oct-Feb, Third crop: Feb-May*

Note: Indian Agricultural Research Institute has developed a cherry tomato variety "Pusa Cherry-1"which yields 2.5 - 3.0 tonnes fresh fruits from 1000 m^2 area in 9-10 months crop duration.

Capsicum

Cucumber

Tomato

Protected cultivation of flower crops under naturally ventilated polyhouse

Flower cultivation has emerged as an alternative high income crop in NCR during the last one decade and demand for various cut flowers has also increased manifold. The major share among these cut flowers is governed by rose, chrysanthemum, gerbera and carnation. Rose, chrysanthemum and gerbera are highly remunerative while cultivated in climate-controlled greenhouse and fetch handsome income at cost-benefit ratio of 1:3.6, 1:6.2 and 1:3.7, respectively.

Economics of flower cultivation in naturally ventilated polyhouse (per 1000 m^2 area)

Components	Rose	Chrysanthemum	Gerbera
Crop duration	3-4 years	8-9 months	2-3 years
Suitable varieties	First Red, Grand Gala	Thai Chin Queen, Zembla	Sangria, Cabana, Jaffa
First harvesting	After 60 days, regular supply	45 days after planting	After 60 days, regular supply
Expected yield	2,50,000 stems	60,000 stems	2,40,000 stems
Total cost of production (₹)	₹ 2,50,000/-	₹ 1,80,000/-	₹ 2,85,000/-
Expected gross income (₹)	₹ 6,00,000/-	₹ 4,90,000/-	₹ 4,50,000/-
Expected net return (₹)	₹ 3,50,000/-	₹ 3,10,000/-	₹ 1,75,000/-
Cost-benefit ratio	1:3.6	1:6.2	1:3.7

Rose

Chrysanthemum

Gerbera

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

Under north Indian plains there is severe winter during December and January months. An off-season cultivation of cucurbitaceous vegetables like summer squash, bottle gourd, cucumber, tomato and French bean etc can be taken up during severe winter using different protected structures. Farmers can earn higher profit due to high price for off-season produce in the market.

Walk-in tunnel, which is a temporary structure made up of G. I. pipes and transparent polythene, can be used for off-season cultivation of vegetables like summer squash, bottlegourd, cucumber etc. during winter season (December-January) to fetch high price for off-season produce and to earn higher profit per unit area. This structure is very useful and profitable for vegetable growers.

Optimum size and fabrication of walk-in tunnel

Optimum size : 25m x 4m (100 m^2)
Design : Semi-circular
Height : 1.8 m (in middle)
Width : 4.0 m
Length : 250 m

Required material and cost

S.No.	Required material	Quantity	Rate (₹)	Expenditure (₹)
1.	G.I. pipe (length 6 m x 12.7 mm diameter)	10 pipes	600/pipe	6,000/-
2.	Plastic sheet (transparent 200 micron thickness size 30 m x 7 m)	210 m^2	50	10,500/-
3	Other fixing material (iron rods of 3 m length and plates)	20 pieces	Lump sum	750/-
4.	Labour (one day)	2 laboures	300	600/-
	Total			**₹17,850/-**

This temporary plastic structure is erected over the crop during the peak winter months of December to mid-February and thereafter, the structure can be removed from the crop. The plastic sheet can be reused for 4-5 years. Walk-in tunnel is suitable for growing off-season vegetable under north Indian plains and lower hills.

Off-season vegetables suitable for growing under walk-in tunnel

S. No.	Crop	Planting time	Crop availability	Yield (t/ha)	Net profit (₹in lakh/ha)
1.	Summer squash	November - December	February - April	40-50	2.0-2.5
2.	Bottle gourd	October - November	February - May	25-30	2.5-3.0
3.	Cucumber	October - November	December - March	15-30	1.0-1.5
4.	Pumpkin	November - December	February - May	30-40	1.5-2.0
5.	French bean	October - November	December - March	6-8	1.0-1.25
6.	Tomato	October - November	February - May	20-25	1.0-1.5

Insect-proof net house for healthy nursery raising

During rainy season under open environment, it is possible to grow a healthy and virus-free nursery in a simple insect-proof net house by the use of an insect-proof nylon net. During 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 40-45% shade net covering. Contrary to this during critical winters nursery of various vegetables like tomato, capsicum, brinjal, cucurbitaceous crops and cucumber can be raised by covering the insect-proof net house with 200 micron thickness plastic sheet. By doing slight modifications we can raise healthy virus-free nursery round the year in a single structure.

Fabrication of insect-proof net house

Optimum size	:	12.5 m x 4.0 m (50 m^2)
Design	:	Semi-circular
Height	:	1.8 m (in middle)
Gates (double)	:	1.6 m x 1.0 m
Net/shade net/plastic	:	80m^2
Life span	:	8-10 yrs

Required material and cost

S.No.	Required material	Quantity	Rate (₹)	Expenditure (₹)
1.	G.I. pipe (length 6 m x 12.7 mm diameter)	6 pipes	600	3,600/-
2.	Insect-proof net (40 mesh, UV stabilized)	100 m^2	50	5,000/-
3	Black or green shade net (50 % shade)	80 m^2	30	240/-
4.	Transparent plastic sheet (200 micron)	80 m^2	50	4,000/-
5.	Fixing material (plates, nut bolts)	As per need		500/-
6.	Labour (skilled labour required)	2 days/ 2 labourers	300	1,200/-
7.	Miscellaneous expenditure	2 labourers		2,000/-
	Total			**₹16,540/-**

Objectives and utility of insect proof net house

1. A net house of 50 m^2 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 fixed duration of 30-35 days after covering the insect-proof net with 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 borne 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/-

Modern polyhouse nursery

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 gap. 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 g/kg seed) 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 ¾th of the block for the female and ¼th 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 behaviour.

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 labeled 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 ochre brown and at least 4-5 times.

Emasculated bud

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.

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
Honeybee hives	:	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

Seed Quality Enhancement Techniques

Seed enhancement treatments are post harvest treatments which improve germination, field emergence, seedling development and establishment, early vegetative growth and crop productivity. These techniques are also useful in the maintenance of seed quality during storage.

The advantages of seed enhancement treatments are: Rapid and uniform germination as well as seedling establishment under optimum and sub-optimum conditions:

- Reduced interval between sowing and seedling emergence
- Increased early vegetative and root growth
- Improvement in reliability of plant stand establishment
- Protects the seed from abiotic and biotic stresses
- Higher crop yields and quality
- Protection from insect-pests and diseases
- Better seed storage potential

Commonly used seed enhancement treatments are seed priming, seed treatment with chemicals, botanicals, biologically active microorganisms, polymer coating, pelleting and magnetic treatment.

Maize

Seed enhancement treatments increased total field emergence, speed of emergence, early seedling and root growth (length, surface area and volume), plant height and seed yield (no. of cobs/plot) over control. These treatments induced early flowering (anthesis, silking) by 1-2 days as compared to control, which could be adopted for synchronization of flowering among parental lines during hybrid seed production.

Effective seed treatments

- Hydro priming (17h) + Thiram (3g/kg of seed)
- Magnetic treatment (1000G/2h)
- Cruiser (5ml/kg of seed)

Chickpea

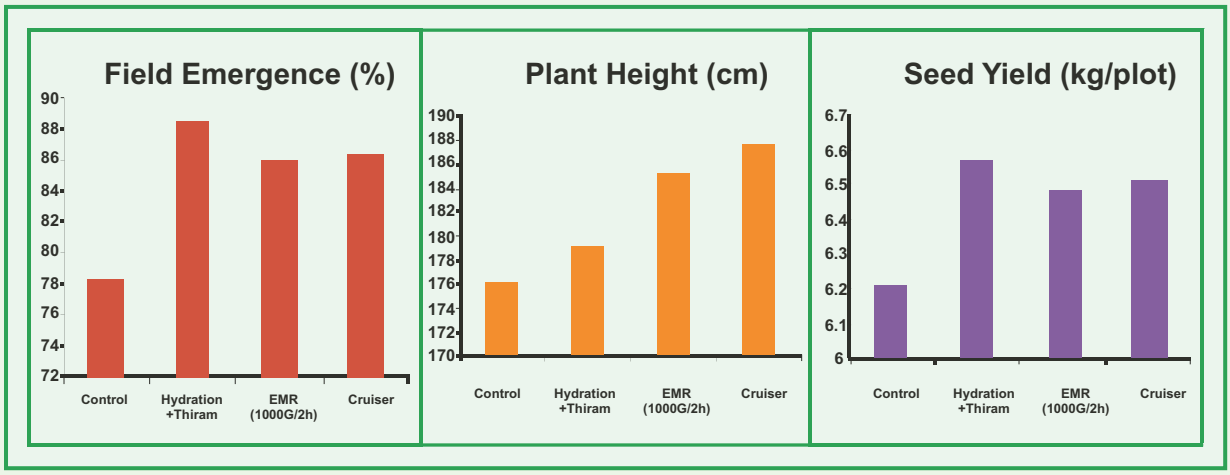
Chickpea seeds both *desi* and *kabuli*) treated with botanicals (Garlic, Ginger, Turmeric) and biologically active microorganisms *(Trichoderma harzianum)* showed increased field emergence, speed of emergence, seedling fresh and dry weight, root growth, early and uniform flowering and yield. Better nodulation was recorded in seeds treated with garlic extract, turmeric extract and priming treatments.

Effective seed treatments

- Dry dressing with Thiram (3g/kg of seed)
- Garlic (10 g/kg seed) + with/without polymer (Polykote)
- *Trichoderma harzianum* (@ 10g/kg seed)

Uniform field emergence in treated plot

Uniform crop stand in treated plot



Effect of seed enhancement treatments on field performance of maize

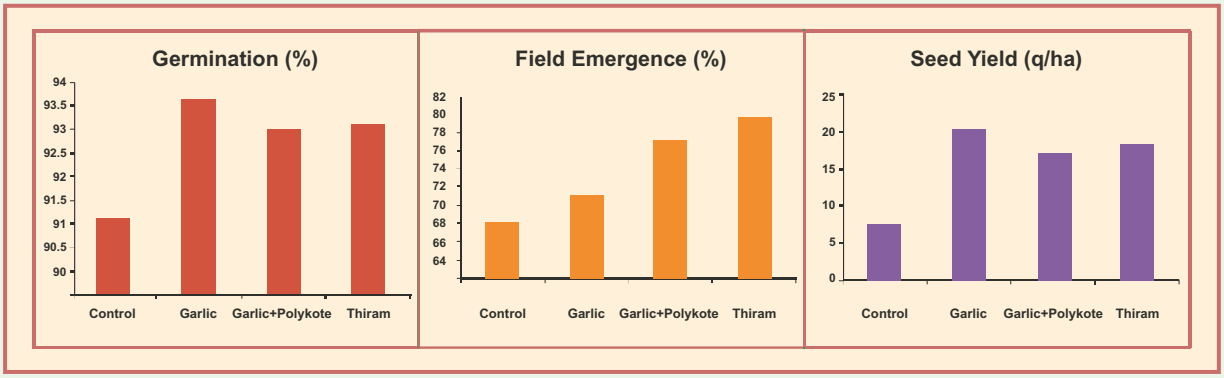
Chickpea

Chickpea seeds both desi and kabuli) treated with botanicals (Garlic, Ginger, Turmeric) and biologically active microorganisms *(Trichoderma harzianum)* showed increased field emergence, speed of emergence, seedling (fresh and dry) weight, root growth, early and uniform flowering and yield. Better nodulation was recorded in seeds treated with garlic extract, turmeric extract and priming treatments.

Effective seed treatments

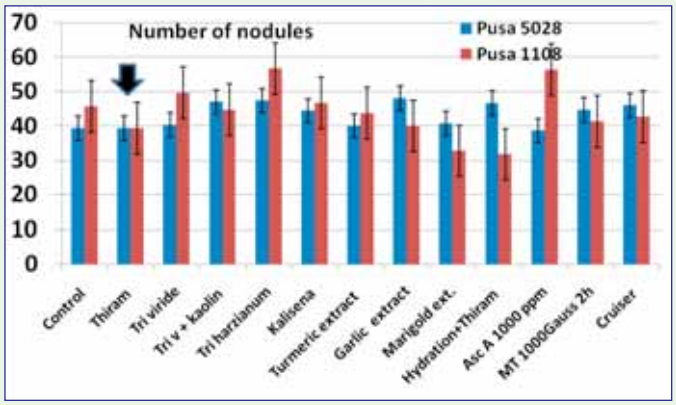
- Dry dressing with Thiram (3 g/kg of seed)
- Garlic (10 g/kg seed) + with/without polymer (Polykote)
- *Trichoderma harzianum* (@ 10 g/kg seed)

Effect of seed treatment with botanicals on field establishment of chickpea



Effect of seed treatments on field performance of chickpea

(A)



(B)

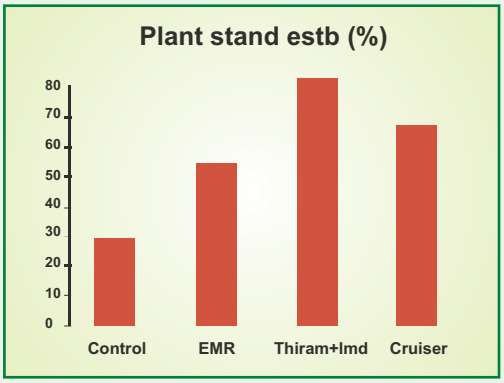
(A) Field trial and (B) response of chickpea varieties in nodulation to various seed priming treatments

Cotton

High temperature during sowing affects seedling establishment. Seed treatment with Thiram + Imidacloprid gave better seedling establishment under field conditions.

Soybean

Seeds treated with Magnetic treatment + polymer (Power Coat 105) + Cruiser (5ml/kg of seed) resulted in higher plant stand establishment.



Effect of seed treatment on field performance of cotton

Hybrid Seed Production in Bittergourd under Insect-Proof Nethouse

IARI has developed and released two bitter gourd hybrids; 'Pusa Hybrid-1' and 'Pusa Hybrid-2' for cultivation under North Indian conditions. Bittergourd hybrid seed production under open field conditions bears losses due to heavy insect-pest attack which affects fruit quality, yield and seed quality. A low cost net house for hybrid seed production is easily adaptable and remunerative for small farmers, particularly, in the peri-urban areas.

Insect-proof net house is a dome shaped protected structure constructed with galvanized iron frame covered with insect-proof net (35-40 mesh/inch^2) which prevents entry of insects, hoppers, aphids and restricts transmission of diseases. The approximate cost of construction of net house with galvanized iron frame (20 m x 5 m x 6 m) is about ₹ 50,000/-. Hybrid seed production under net house is a profitable and environment friendly technology wherein the crop remains more vigorous, insect free, exhibited higher fruit and seed yield with better seed quality as compared to open field condition. It also helps in reducing cost of seed production and indiscriminate use of pesticides for insect and pest control. The plants produced more crossed fruits with higher fruit weight, seed yield/fruit (more filled seed) and quality.

The hybrid seed production technology of bittergourd under net house conditions is given below:

Season: Bittergourd is a warm season crop, requires temperature above 25 ^{O}C for optimum growth, flowering and seed setting. Seed production is feasible in both summer and *kharif* season but summer season is better for seed production.

Isolation distance: Male and female parental line blocks should be separated by 5 m.

Seed source: Genetically pure and certified/ authentic seeds of parental lines should be procured from the Breeding Institutes, Seed Corporations, Agricultural Universities or Seed companies.

Planting ratio: 3:1

Sowing: Seeds should be soaked and treated with Bavistin (2.5 g/kg of seed) and sown on raised planting beds (1.5 m wide) at a distance of 1m (plant to plant). 21 days old seedlings raised in plug trays can also be transplanted on raise beds under net house conditions.

Summer Crop: 15th February to 30th February

Winter Crop: 15th July to 31st July

IARI released hybrids: Pusa Hybrid 1 and Pusa Hybrid 2 under nethouse

Hybrid seed production under net house

Male and female flower for hybrid seed production

Irrigation: Beds should be irrigated immediately after sowing/transplanting and at interval of 15-20 days.

Intercultivation: Three to four inter culture operations should be done to remove weeds and loosen soil. Earthing up should be done before flowering for better crop establishment and flower induction.

Hybrid Seed Production: Bittergourd is a highly cross pollinated crop. Female and male flowers are borne on different nodes of a vine. Hybrid seed production is done by manual hand pollination. For successful hybrid seed production, pollination should be initiated one week after first female flower opening in a vine. All opened flowers and selfed fruits should be removed from female parent before pollination. Unopened female and male buds are covered with butter paper bag and cotton respectively to prevent contamination. Pollination should be done next day morning between 7 am - 12 noon. Male flower is plucked from vine and pollen is dusted on stigma of female flower manually. Pollinated flowers are covered with butter paper bag to prevent contamination.

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

Fruit Setting: Pollination activity can be undertaken up to 30th October but maximum fruit and seed setting could be achieved from flowers crossed between 1st September to 15th October under north Indian conditions.

Fruit retention: 14-16 fruits/vine should be retained for higher seed yield and quality.

Harvesting: 25-30 days after pollination when fruits turn orange.

Seed extraction: Seed extraction is done manually by opening the ripe fruit and removing the seeds followed by macerating it with sand to remove red seed coat. Extracted seeds are shade dried before packaging.

Seed Yield: 2.5 kg/100 sq m

Economic returns per unit area

On an average, a yield of 2.5 kg of hybrid seed/100 sq m area of net house can be achieved per season. A farmer can earn ₹ 10,000 (5 kg seed /year (2 seasons) @ ₹ 2,000/kg of seed). The net house can be retained for 3-4 years with minor repair, thus the returns on seed production increase in the following years.

Benefit cost ratio: 2.3: 1.0.

Vine with crossed fruits and matured hybrid seed

Value Addition of Fruits and Vegetables

Adoption of post-harvest management practices not only help farmers in saving enormous loss of horticultural produce but also help in securing higher remuneration through proper pre-harvest management and development of value added products. Some of the salient post-harvest technologies developed at IARI, New Delhi are mentioned below:

Developed technology and 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 ^{O}Brix, 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-eat flaked soy

Technology for preparing ready-to-eat products from soy

Soybean
↓
Cleaning & Grading
↓
Soaking
↓
Tempering
↓
Flaking
↓
Roasting
↓
Flaked soy

Benefits

- Rich in quality protein & fat
- Rich in micro-nutrients
- Rich in antioxidants & flavonoids
- Long shelf-life

Flaked soy

Antioxidant-rich functional food from *aonla*

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

Advantages

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

Antioxidant-rich *aonla* candy

Fresh *aonla*

Pusa pearl puff

Process

Ingredients
↓
Cleaning
↓
Grinding
↓
Mixing
↓
Conditioning
↓
Extrusion
↓
Drying
↓
Spicing
↓
Packaging

Benefits

- Rich in micro-nutrients, especially Fe, Zn and Ca
- Consumption of 100g of this product can meet approximately 25% of the RDA of Fe and Zn in women
- Free from anti-nutrient factors
- Gluten free and can be a boon to people suffering from celiac disease
- Free from any artificial colour, flavour or preservatives
- Highly acceptable by people of different age groups
- Long shelf life

Pusa pearl puff

Pusa pearl pasta

Process

Raw ingredients
↓
Cleaning
↓
Grinding
↓
Mixing
↓
Conditioning
↓
Extrusion
↓
Drying
↓
Packaging

Benefits

- The product consists of quality protein
- It has low gluten load
- It contains minerals like iron and zinc
- It is free from any synthetic colour and flavor
- It contains functional ingredients to fight against various diseases
- It has long shelf life

Pusa pearl pasta

Pusa soya nut

Benefits of Pusa soya nut

- Rich in quality protein and fat
- Unique source of flavonoids, reduce cholesterol, inhibit bone deterioration, relieve menopause symptoms and possess anti-cancer activity
- Rich in total antioxidants and phenolics
- Highly acceptable among different age groups
- It is free from any off flavour
- TIA has been reduced by 90%

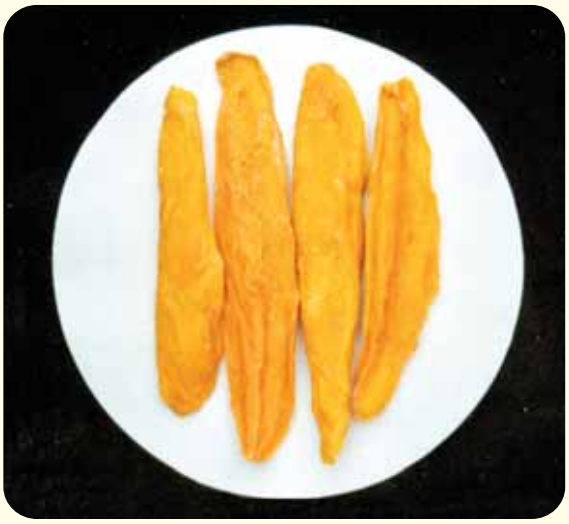
Pusa soya nut

Dehydrated ripe mango slices

Due to excellent flavour, fragrance, taste and nutritive value, mango is the choicest fruit among the consumers in India. It has great potential for value addition and diversification to give a boost to food industry, create employment opportunities and give better returns to the farmers. Mango is used as fresh or in processed form into several value added products such as pickles, *amchur,* squash, *panna* etc. Recently, the Institute has developed 'Dehydrated Ripe Mango Slices and Powder' technology.

Uniqueness of the technology

The dehydrated ripe mango slices could be converted into powder, which can be used as a base material for the development of beverages and as a source of raw material when the fresh mangoes are not available. Mango powder is considered to be very healthy and can be used by all age-groups. It is rich in calcium, vitamin A and C. It can be used in the preparation of mango milk shake, juice mix, *sharbat,* ice creams, flavoured food items, weight reduction products, biscuits etc. Production of dehydrated ripe mango slices and powder is one of the sectors, which can utilize a lot of unmarketable mango fruits during the peak season and can add value by converting them into processed products.



Dehydrated mango slices

Advantages of the technology

- Developed products can be stored for a longer time
- These products can be used for the preparation of tasty drinks, healthy dishes, and many other delicious food products like mango ice cream, mango custard powder, mango shake, mango toffee, mango yoghurt.
- The product retains the original colour and flavour of mango
- The product can be used in off season when mangoes are not available
- It is a ready-to- eat product having crisp texture
- This product can be a good adjunct in the ice cream industry
- More economical compared to bulk mango pulp

Anthocyanin concentrate and its value added products

- Black carrot and *Jamun* are excellent source of anthocyanins, source of natural food colorant
- Anthocyanin provide health benefits due to their significant antioxidant activity and their ability to promote immune systems
- Anthocyanin concentrate has been purified to obtain crystalline anthocyanin powder
- Nutraceutical enriched processed foods, beverages, *jams*, candy, pro-biotics, and frozen foods like ice creams/ yogurts by imparting pleasing pink/ purple colour have been prepared
- The novel guava and green grape based nectars have been enriched with natural antioxidants and food colorants.
- Anthocyanin enriched *aonla* candy possess the biologically active components from *aonla* and black carrot.

Production of lycopene from tomato and its products

- Tomato is a rich source of lycopene, an excellent natural antioxidant and a food colorant.
- Lycopene exhibits anti-cancer properties and thus used as ingredient in the preparation of Ayurvedic preparations for the control/prevention of prostate gland and other cancers, ulcers, macular degeneration etc.
- Red capsicum and tomato can be value processed into a delicious salsa sauce which has a rich red color and a unique flavour.
- Capsicum-tomato *salsa* is a rich blend of health promoting antioxidants such as capsanthin and lycopene, phenolics and vitamin C and has higher nutrition value than even the popular tomato sauce.

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

Pusa Zero Energy Cool Chamber

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

Fruit bagging in apple

Red coloured apple are preferred in the market as red colour is the central point of attraction to the consumers. At lower hills, colour development in apples is not adequate, and hence majority of the farmers use ethrel (2-Chloroethyl Phosphonic Acid) as pre-harvest foliar spray for colour enhancement of the fruits. Ethrel, although, helps in development of attractive red colour in apple fruits, causes several adverse effects, e.g. it enhances fruit drop, pre-mature leaf-fall. Besides, the harvested fruits are of poor keeping-quality. Further, ethrel treated apples need to be harvested at a stretch to get desirable price in the market. Moreover, the residues of ethrel, if any, may be injurious to human health. Further, during storage, apples suffer from several diseases and disorders for which various chemicals and pesticides are used, which are also injurious to human health. Hence, efforts have been started world over to find out some non-chemical approaches to reduce the incidence of diseases and disorders in fruits including apple. Fruit bagging has been proved to be very useful practice in studying anthocyanin synthesis pathway in apple and reducing the incidence of insect-pests, sun scorching, fruit splitting in several other fruits. Bags of different colours have given different results in fruits crops. Considering these points, the Institute has standardized fruit bagging technology for apple. In this technology, apples fruits are bagged on-the-tree with spun-bounded light-yellow, single layered coloured bags individually or group of 2-3 apples about one month before the expected date of harvesting. During this period, all routine cultural practices are carried out. The bags are removed at least 3 days before the expected date of harvesting.

Advantages of the technology

A view of fruit bagging in apple

- It is a probable alternative to ethrel treatment in lower hills.
- Bagging improves appearance of apples significantly, which helps in getting good price in the market.
- Bagging reduces residues of pesticides significantly.
- Bagging reduces the incidence of insect-pests and diseases, thereby reduces the expenses. involved in purchasing insecticides, fungicides and other chemicals.
- Fruit bagging can be an integral part of organic apple production.
- Bags are recyclable, can be used for 3-4 successive seasons.
- Farmers can additionally earn ₹ 30-35 thousands per ha.
- Bagging improves eating quality of apples.
- Bagged apples have higher shelf-life.
- Bagged fruits are nutritionally better as they contain higher levels of calcium and that is retained during storage also.
- Incidence of storage disorders is reduced to minimum by bagging.

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/- per box)	= ₹ 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/-	**Income**		**Income**	
Total Expenditure	**= ₹ 83,000/-**	Honey production = 1500 kg		Honey production = 1600 kg	
Income		Income from sale of honey (@ ₹ 80/- per kg)	= ₹ 1,20,000/-	Income from sale of honey (@ ₹ 80/- per kg)	= ₹ 1,28,000/-
Honey production = 750 kg		No. of additional colonies obtained =35		No. of additional colonies obtained = 30	
Income from sale of honey (@ ₹ 70/- per kg)	= ₹ 52,500/-	Income from sale of 35 colonies	= ₹ 1,05,000/-	Income from sale of 30 colonies (@ ₹ 3,500 per box)	= ₹ 1,05,000/-
No. of additional colonies obtained = 20		Total income = ₹ 1,20,000 +1,05,000/-	= ₹ 2,25,000/-	Total income	= ₹ 2,33,000/-
Net income = (-) ₹ 30,500 + 20 colonies		**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 1,50,000 tonnes (2012-13). 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°C and 14-18°C respectively along with 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°C and 22-25°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:

Mushroom house

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.

Fully grown mushroom

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.

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°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, 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 °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°C and maintain it between 14 and 18°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 °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

Compost

Laser land leveller

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 using rock phosphate and waste mica

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 weight 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.

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 vermicomposting

- Two weeks old farm yard manure
- Fruits and vegetables waste
- Crop residue and 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 one is Red worm *(Eisenia foetida)* which 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.

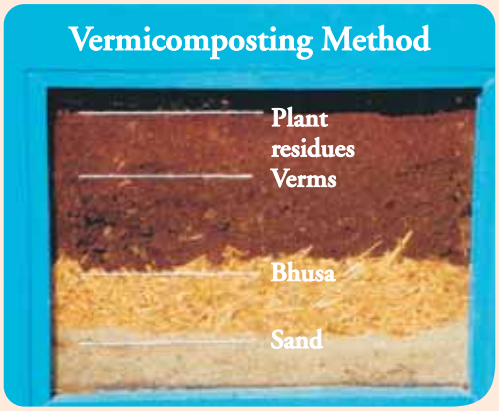
Eisenia foetida for vermicomposting

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 regenerate 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 g/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

Ready-reckoners for soil test based fertilizer recommendations for wheat

The fertilizer recommendations based on targeted yield approach are not only balanced but also remove the arbitrariness in fertilizer recommendations and ensure the yield that could be achieved. It provides the basis where fertilizer recommendations can be tailored to the need, management and input investment capacity of the farmers. Ready reckoners were prepared from the fertilizer adjustment equations, for different soil test values, which will provide a working basis for soil testing laboratories for making fertilizer recommendations based on targeted yield. This recommendation is applicable for Delhi and adjoining areas having similar soil agro-climatic conditions. The requirement of fertilizers decrease with the increase in soil test values.

Soil test based fertilizer adjustment equations

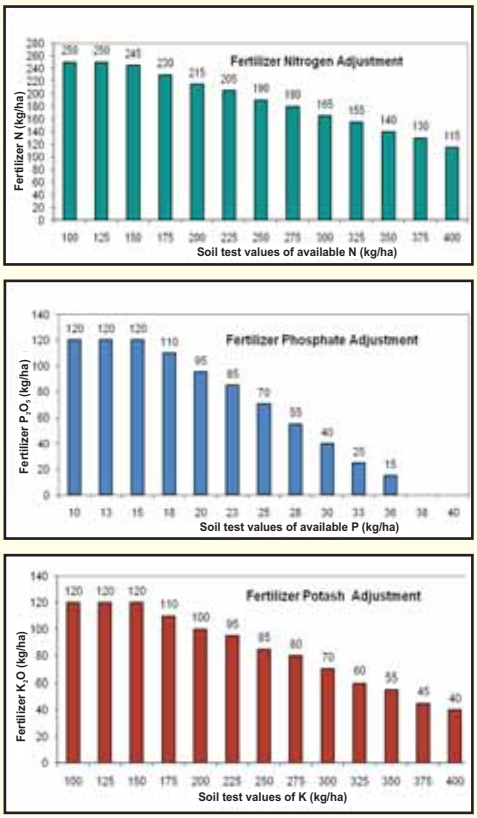
Wheat

FN = 5.31T - 0.51 SN

FP_2O_5 = 3.45T - 5.55 SP

FK_2O = 2.75 T- 0.32 SK

Where FN, FP_2O_5 and FK_2O = fertilizer dose (kg/ha), SN, SP and SK = soil test values (kg/ha), T stand for targeted yield of the crop in q/ha and amount of N added through DAP will be adjusted.



Fertilizer recommendations based on soil test for targeted yield of wheat (60 q/ha)

Cost benefit ratio of phospho-compost

Raw materials required for preparation of one tonne of nutrient enriched compost

Material	Amount (in kg)	Estimated cost (₹)
Crop residue	1800	Nil
FYM/Poultry droppings/Cow dung	200	600
Rock phosphate	50	500
Compost inoculant	0.50	30
Total cost (₹)		1130

Market price of nutrient enriched compost		
Market price of 1000 kg compost @ ₹ 3/kg	:	₹ 3,000/-
Input Cost	:	₹ 1,130/-
Profit	:	₹ 1,870/-

Resource Conservation Technologies

i) Zero–tillage technology

- In zero tillage (ZT) technology, soil is not ploughed, but sowing of crop is done by using a specially designed zero-till seed-cum-fertilizer drill/planter, which disturbs soil to the least possible extent. At the time of seeding, fertilizers are simultaneously placed beneath the seeds. Several modern seeding machines, such as happy seeder, turbo seeder, multi-crop planter, roto-double disc planter are necessary for sowing in residue-laden conditions.
- Zero tillage proves better for direct-seeded rice, maize, soybean, cotton, pigeonpea, mungbean, clusterbean, pearlmillet during *kharif* season and wheat, barley, chickpea, mustard and lentil during *rabi* season.
- Wheat sowing after rice can be advanced by 10-12 days by adopting this technique compared to conventionally tilled wheat, and wheat yield reduction caused by late sowing can be avoided. ZT provides opportunity to escape wheat crop from terminal heat stress.
- Zero tillage reduces cost of cultivation by nearly ₹ 2500-3000/ha through reduction in cost of land preparation, and reduces diesel consumption by 50-60 litres per hectare. Besides, wear and tear losses of tractor and machinery are minimized.
- Zero tillage reduces water requirement of crop and the loss of organic carbon by oxidation. It increases the activity of micro-flora and fauna with crop/plant residues/stubbles or other vegetative cover retained on soil surface. This provides favorable effect on crop root development and subsequent growth and enhances the production potential of soil under zero tillage.
- Zero tillage reduces *Phalaris minor* problem in wheat. Isoproturon resistance to this weed can be overcome through ZT. Initially, for controlling weeds, non-selective herbicides like paraquat, glyphosate may be applied at 1.0 kg/ha at 7-10 days before sowing of seed, followed by application of crop-selective herbicides.
- Bulk density, penetration resistance, and soil compaction are significantly lower in zero-till with residues compared to conventional till wheat in direct seeded rice - wheat system.
- The carbon status of soil is significantly enhanced in surface soil (0-5 cm), particularly under crop residue retention with zero tillage.

Wheat is being sown by Turbo Seeder

Broad bed planting by zero tillage with residue

Wheat crop under zero till with rice residue

ii) 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 cotton, maize, pigeonpea, green gram, soybean, cowpea, vegetables, 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.
- Bed planting system helps in efficient use of water under rainfed as well as irrigated conditions because of optimum water storage and safe disposal of excess water.
- Furrow irrigated raised-bed system (FIRBS) of wheat usually saves seed by around 25%, water by 25-30% and nutrients by 25% without affecting wheat grain yield. It reduces weed populations on the top of beds, and lodging of wheat crop.
- The productivity of cotton-wheat, pigeonpea-wheat and maize-wheat systems is higher under ZT bed planting with crop residue than in CT flat sown crops. In cotton-wheat cropping system, zero till-broad bed + residue is more remunerative, giving higher system productivity, net returns, and system water productivity than those in conventional till-flat planting.
- Cotton-wheat cropping system under ZT broad bed with residues of both crops gave higher system productivity and net returns than that in the transplanted rice-conventional till wheat cropping system. Therefore, it can be an alternative option for rice-wheat system under irrigated conditions.
- The zero till-broad bed + residues results in several benefits: better soil structures/aggregates, higher soil organic carbon and higher energy productivity & energy-use efficiency.

Cotton crop under zero till-broad bed + residue

A view of bed planted wheat

iii) Direct-seeded rice

- Direct-seeded rice (DSR) avoids water required for puddling and reduces overall water demand compared to conventional puddled transplanted rice (TPR).
- DSR is a labour-, fuel-, time-, and water-saving technology, which gives comparable yield as that of TPR.
- Soil health is maintained or improved, and fertilizer and water-use efficiencies are higher in DSR (saving of 30-40% irrigation water). Therefore, DSR is a technically and economically feasible alternative to TPR.
- The wet season DSR should be planted 10-12 days before the onset of monsoon. In North Indian conditions, summer mungbean can be adopted before DSR. It gives grain yield of 0.8-1.0 t/ha and usually adds 40-60 kg N/ha in soil, reducing N requirement for the subsequent crop.
- Summer mungbean residue incorporation/retention in DSR and rice residue in zero-till wheat followed by zero-till summer mungbean with wheat residue proves superior to TPR-conventional tilled wheat system in terms of system productivity, net returns and system water productivity.

iv) 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 mungbean and cowpea during summer is better than *Sesbania* green manuring or fallow for improving the productivity and profitability.

Higher income through Crop Diversification

- 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.
- Cotton-wheat, pigeonpea-wheat, maize-vegetable pea / potato-sunflower, soybean-vegetable pea / potato-sunflower and groundnut-wheat-mungbean cropping systems are economically acceptable and environmentally sustainable option for rice-wheat system.
- 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.
- Intercropping of radish is more profitable in *rabi* maize and a net income of ₹40,000-50,000 can be obtained with this system.

Nutrient Management for Improving Productivity and Profitability

i) Use of zinc- and neem-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.
- 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.

ii) 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%.

iii) 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.

Weed Management

i) Control of *Parthenium hysterophorus* in non-cropped areas

- 100 per cent control of *Parthenium* can be achieved with the application of metribuzin at 1.0-1.5 kg a.i. per hectare within two weeks or with 0.5% concentration.

- Control of *Parthenium* in non-cropped areas can also be achieved with a spray of 10 % urea or common salt solution.

ii) Weed management in onion

- Sequential application of pendimethalin @ 0.75 kg/ha as pre-emergence followed by pendimethalin @ 0.75 kg/ha as broadcast (sand mix) 40 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.

iii) Weed management in maize

- Tank mix pre-emergence application of atrazine + pendimethalin (500 +750 g/ha) has proven a viable technology for season long weed free condition in both *kharif* and *rabi* maize in maize growing areas of the country particularly in Bihar, Karnataka.

iv) Efficient weed control using herbicides in gladiolus

- A tank-mix pre-emergence application of pendimethalin 0.75 kg/ha + metribuzin 0.3 kg/ha results in significantly greater gladiolus plant height, cut-flower yield, corm yield and net returns, and is most remunerative.
- An application of atrazine @1.0 kg/ha pre-emergence followed by residue retention @ 5 tonnes/ha, which results in lower weed competition, maximum spike length (101cm) and comparable cut-flower yield, could be an alternative to this.
- This tank-mix application is more effective than any single herbicide application and does not pose any phytotoxicity to gladiolus plants.

v) Herbicide tank-mixes for better 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 pendimethalin (750 g/ha) + imazethapyr (100 g/ha) as pre- emergence is highly effective against composite weeds including *Cyperus rotundus* in soybean.

vi) 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.

Profitable Crop Rotations

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

Crops/cropping systems	Average yield (t/ha)	Sowing time	Harvesting time	Net returns (₹/ha)
Mono-cropping system				
***Kharif* crops**				
Pearl millet	1.8-2.0	July	October	17,000-20,000
Maize	2.0-2.2	July	October	17,000-21,000
Pigeonpea	1.2-1.5	June-July	December-January	40,000-45,000
Green gram/black gram/cowpea	0.8-1.0	July	September	27,000-30,000
Groundnut	1.2-1.5	July	October	35,000-45,000
Soybean	1.6-1.8	July	November	30,000-34,000
Clusterbean	1.0-1.5	July	October	30,000-50,000
***Rabi* crops**				
Toria	0.7-0.8	September	December	12,000-17,000
Mustard	1.2-1.5	October	March	22,000-25,000
Taramira	0.7-0.8	October	March	10,000-13,000
Chickpea	1.2-1.5	October	March	25,000-32,000
Lentil	0.8-1.0	October	March	14,000-18,000
Linseed	0.8-1.0	October	March	10,000-16,000
Wheat	2.0-2.5	October-November	April	25,000-30,000
Intercropping system				
Pearl millet + green gram	1.2-1.5 + 0.3-0.4	July	October	20,000-24,000
Pigeonpea + green gram/ black gram/groundnut	1.0-1.2 + 0.3-0.4	July	December	45,000-50,000
Mustard + gram	0.4-0.6 + 0.8-1.0	October	March	26,000-30,000
Wheat + mustard	1.8-2.0 + 0.3-0.4	October	April	30,000-34,000
Mustard + lentil	0.4-0.6 + 0.6-0.8	October	March	22,000-27,000
Chickpea + linseed	0.8-1.0 + 0.4-0.5	October	March	25,000-30,000
Sequential cropping system				
• Green gram/black gram	0.8-1.0	July	September	50,000-60,000
Mustard	1.0-1.5	October	March	
• Maize	2.0-2.2	June end	September	35,000-45,000
Wheat/barley	1.5-1.8	October	April	
• Maize	2.0-2.2	June end	September	40,000-50,000
Mustard/chickpea	0.8-1.0	October	March	
• Pearl millet	1.8-2.0	July	September	38,000-48,000
Mustard/chickpea	0.8-1.0	October	March	

Suitable cropping systems for irrigated Indo-Gangetic plains

Crops/cropping systems	Average yield (t/ha)	Sowing time	Harvesting time	Net returns (₹/ha)
Double cropping system				
● Basmati rice	3.5-4.0	June / July	November	1,10,000-1,30,000
Wheat	4.0-4.5	November	April	
● Basmati rice	3.5-4.0	June / July	November	1,00,000-1,30,000
Sunflower	2.0-2.2	February	May	
● Hybrid rice	6.0-7.0	June	October	1,20,000-1,40,000
Wheat	4.5-5.0	November	April	
● Rice	5.0-6.0	June / July	October	90,000-1,10,000
Wheat	4.5-5.0	November	April	
● Rice	5.0-6.0	June / July	October	95,000-1,10,000
Berseem (fodder + seed)	40-50 + 0.4-0.5	October	May	
● Maize	4.0-4.5	June	October	90,000-95,000
Wheat	4.5-5.0	November	April	
● Pigeonpea	1.8-2.0	June	November/December	1,05,000-1,20,000
Wheat	4.0-4.5	December	April	
● Cotton	2.0-2.5	May	November/December	1,10,000-1,25,000
Wheat	4.0-4.5	December	April	
● Groundnut	1.8-2.0	July	October	1,00,000-1,15,000
Wheat	4.5-5.0	November	April	
● Rice	5.0-6.0	June/July	October	75,000-85,000
Chickpea	1.2-1.5	October	April	
● Soybean	2.0-2.5	July	November	80,000-95,000
Wheat	4.5-5.0	November	April	
● Soybean	2.0-2.5	July	November	90,000-1,10,000
Potato	22-28	November	February/March	
Triple cropping system				
● Green manuring (*Dhaincha*/sunnhemp/cowpea)		April/May	June	95,000-1,15,000
Rice	5.5-6.0	June/July	October	
Wheat	4.5-5.0	November	April	
● Fodder (cowpea + *bajra*/maize/*jowar*)	3.0-3.5	April	June	1,10,000-1,20,000
Maize	4.0-4.5	July	October	
Wheat	4.5-5.0	November	April	
● Green manuring (*Dhaincha*/sunnhemp/cowpea)		April/May	June	95,000-1,00,000
Maize	4.5-5.0	July	October	
Wheat	4.5-5.0	November	April	

Crops/ cropping systems	Average yield (t/ha)	Sowing time	Harvesting time	Net returns (₹/ha)
● Maize	4.0-4.5	Mid June	September	1,30,000-1,50,000
Potato	18-20	September-end	December	
Wheat	3.5-4.0	December	April	
● Rice	5.0-6.0	July	October	1,10,000-1,30,000
Potato	20-22	October	February	
Green gram	0.8-1.0	March	June	
● Maize	4.5-5.0	July	October	1,15,000-1,40,000
Potato	25-30	October	February	
Green gram	0.8-1.0	March	June	
● Rice	5.0-6.0	June/July	October	1,25,000-1,55,000
Potato	15-18	October	January	
Sunflower	2.0-2.2	February	May	
● Rice	5.0-6.0	June	October	1,10,000-1,20,000
Toria/Mustard	0.8-1.2	October	February	
Sunflower	2.0-2.2	February	May	
● Rice	5.5-6.0	June/July	October	1,20,000-1,40,000
Wheat	4.5-5.0	November	April	
Green gram	0.8-1.0	April	June	
● Maize	4.5-5.0	July	October	1,10,000-1,25,000
Wheat	4.5-5.0	November	April	
Green gram	0.8-1.0	April	June	
● Maize	4.0-4.5	June	September	1,20,000-1,50,000
Potato	25-30	October	February	
Sunflower	2.0-2.2	February	May	
● Maize	4.0-4.5	June	September	1,10,000-1,30,000
Toria/Mustard	1.5-2.0	October	February	
Sunflower	2.0-2.2	February	May	
● Maize	4.5-5.0	June/July	September	95,000-1,10,000
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	95,000-1,05,000
Mustard	1.8-2.0	October	March	
Green gram/Black gram	1.0-1.2	April	June	
● Maize	4.0-4.5	June	September	1,40,000-1,80,000
Potato	20-25	October	December	
Onion	20-25	January	May	

Quadraple cropping systems

Crops/ cropping systems	Average yield (t/ha)	Sowing time	Harvesting time	Net returns (₹/ha)
● Maize	4.0-4.5	Mid-June	September	1,25,000-1,50,000
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	1,20,000-1,35,000
Toria	0.6-0.8	September	December	
Wheat	3.5-4.0	December	April	
Green gram	0.6-0.8	April	June	
● Maize	4.0-4.5	Mid-June	September	1,25,000-1,40,000
Radish / Turnip	18-22	September	November	
Wheat	3.5-4.0	November	April	
Green gram	0.6-0.8	April	June	

Vegetable-based cropping systems for peri-urban areas

Crops/ cropping systems	Average yield (t/ha)	Sowing time	Harvesting time	Net returns (₹/ha)
● Brinjal	30-35	May-June	September-October	1,30,000-1,50,000
Methi	6.0-7.0	October-November	January	
Bottle gourd	18-20	February-March	April-June	
● *Broccoli*	18-20	October-November	January-February	1,35,000-1,45,000
Tomato	30-32	December-January	May-June	
Baby corn	1.5-1.8	June/July	August-September	
● Spinach	15-20	September-October	December-January	1,15,000-1,25,000
Onion	15-18	December-January	May-June	
Okra	8.0-10	June-July	August-September	
● Radish	20-22	September-October	December-January	1,45,000-1,55,000
Tomato	30-32	December-February	May-June	
Bottle gourd	18-20	June-July	August-September	

Vegetable based-suitable cropping systems

Zone	Cropping system	Average yield (t/ha)	Sowing	Harvesting	Net returns (₹/ha)
Northern plains	Early Cauliflower Peas Tomato	10-12 7-8 40-45	July October January	October January June	2,80,000- 3,20,000
	Okra Carrot Cauliflower Radish	12-14 25-30 25-30 15-18	June October December April	September December March May	2,13,000- 2,57,000
	Cucumber Potato Onion	12-13 16-18 22.5-25	July October January	September December June	2,60,000- 3,00,000
North-eastern region	Cauliflower Peas Radish Capsicum	10-11 8-10 17-20 15-16	June September December January	August November January May	3,00,000- 3,50,000
	Green Chilli Broccolli Radish Bottlegourd	11-12 11-12 15-16 30-32.5	June October January February	September December February May	2,12,000- 2,41,000
North-western hilly region	Frenchbeans Knol-khol Peas Capsicum	10-11 15-16 10-11 15-16	July September November April	September November April June	2,85,000- 3,25,000
	Tomato Cabbage Turnip Potato	35-40 20-22 20-21 25-30	June September November March	September November February May	3,00,000- 3,53,000

Vegetable- and food grain-based suitable cropping systems for north-western plains

Cropping system	Average yield (t/ha)	Sowing	Harvesting	Net return (₹/ha)
Basmati Rice Cauliflower Cowpea	3.5-4.0 25-30 7.0-8.0	June November February	November January April	1,17,000-1,47,000
Basmati Rice Peas Bottle gourd	3.5-4.0 7.0-8.0 30-32.5	June November March	November March May	1,50,000-1,78,000
Basmati Rice Cauliflower Onion	3.5-4.0 25-30 22.5-25	June November January	November January May	1.59,000-1,94,000
Rice Carrot Wheat	5.5-6.0 25-30 3.0-3.5	June September December	September December April	1,45,000-1,75,000

Rice	5.5-6.0	June	September	1,37,000-1,70,000
Cauliflower	15-20	September	December	
Wheat	3.0-3.5	December	April	
Okra	13.0-14.0	June	September	1,35,000-1,62,000
Radish	15.0-20.0	September	November	
Wheat	4.0-4.5	November	April	
Brinjal	35-40	June	September	1,55,000-1,89,000
Spinach	15-17.5	September	November	
Wheat	4-4.5	November	April	

Fruit and food grain based cropping systems

Area	Cropping system	Average yield (t/ha)	Net returns (₹/ha)
Northern Plain Area	Papaya (October transplanted) +	37-45	1,33,000-1,67,000
	Maize +	2.5-3.0	
	Wheat	1.8-2.5	
Eastern Plain Area	Banana +	22-26	1,55,000-2,00,000
	Elephant foot yam +	12-14.5	
	Turmeric	8.5-12	
North-East and South Mid Hilly areas	Banana +	12-15	1,50,000-2,00,000
	Pomegranate +	14-18.5	
	Ginger	7.5-10.5	

Rhizobium

Rhizobium inoculants establish efficient symbiotic association with pulses, leguminous, oil-seed and fodder crops and thus, can fix 20-100 kg N/ha. A well nodulated legume crop also leaves sizeable amount of nitrogen in soil, which can meet a part of N-requirement of the succeeding crop in rotation. A 10-60% 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.

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 micro-organisms in rhizosphere and therefore, reduces the crop damage due to plant diseases. *Azotobacter* helps in maintaining better plant population, growth and improves yield 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, barnyard millet, small millet and oats. Increase in grain and fodder yields of millets due to its inoculation is almost equivalent to that attainable with 15-20 kg N/ha.

Phosphate solubilizing bacteria

Inoculation with an efficient P solubilizing micro-organism improves the availability of phosphorus from its insoluble forms in soil and enhances the use-efficiency of phosphatic fertilizers such as super phosphate.

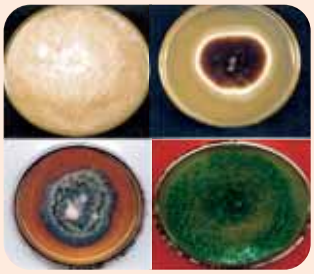
Solubilization of phosphorus by P solubilizing bacteria

Therefore, soil fixed phosphorus is effectively available to the crops, treated by these microorganisms. 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 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-microorganisms.

Phosphate solubilizing bacteria

Compost inoculants

An inoculant, which is a consortium of four ligno-cellulolytic fungi, 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.



Ligno-cellulolytic fungi for composting

Arbuscular-Mycorrhizae (Nutrilink)

Arbuscular-Mycorrhizae (AM) is a specific group of fungi with symbiotic associations with plants. The hypae of AM fungi forms 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 plants. 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. Mix 5.0 kg AM inoculant in soil/FYM/compost/vermicompost in 1:20 ratio and apply near root zone for one acre crop.

AM inoculant

Blue-green Algae

For paddy cultivation, the use of blue-green algal inoculant has been found beneficial. It provides not only nitrogen but also organic carbon and growth promoting substances. After concerted research efforts 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. Mix one packet of 500 g BGA in 4-5 kg soil and broadcast in standing water of one acre paddy field, which gives a benefit of 20-30 kg N/ha.

Blue-green algae

Azolla

Azolla is a free-floating water fern having symbiotic association with *Anabaena*. *Azolla* contributes 40-50 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, subsequent rapid decomposition in soil and efficient availability of nitrogen to the crop.

Azolla

Use of microbial inoculant/culture

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

Liquid Inoculants

Liquid inoculants of *Azotobacter, Azospirillum, Rhizobium* and Phosphate solubilizing bacteria have been developed. These formulations have a considerably enhanced shelf life of more than one year as compared to 6 months of carrier based formulations and contain a very high microbial load of more than 10^{12} cells /ml. It can be applied as seed treatment, root dip for seedlings during transplantation or soil treatment for trees. Dilute 50 ml of formulation with one litre of water and apply on seeds required for one acre of field. Seeds can be sown after 30 minutes.

Liquid formulations of *Rhizobium, Azotobacter, Azospirillum* and PSB

Liquid formulation of Potassium solubilizing bacteria

Potassium is an essential macronutrient required by crops. There are considerable amounts of insoluble K reserves in many soils, most of which exist in alumino-silicate minerals from which K cannot be absorbed directly by plants. K solubilizing bacteria can be applied to all crops and can provide 10-15 kg K/ha. The liquid formulation developed contains highly efficient K solubilizing bacteria that can be used in different types of soils.The formulation has a shelf life of one year.

Liquid formulation of K-solubilizing bacteria

Liquid formulation of Zn solubilizing bacteria

Zinc is required in relatively small concentrations in plant tissues (5–100 mg/kg). Zn deficiency is well reported in the soils of much of the world. The major reason for the widespread occurrence of Zn deficiency problems in crop plants is the low solubility of Zn in soils rather than a low total amount of Zn. Zinc solubilizing bacteria helps to solubilize the fixed form of Zn and increase uptake of Zn leading to fortification of grains with Zn. The product is based on efficient Zn solubilizing culture that contains *Bacillus* species that can solubilize Zinc found in various sources like Zinc oxide, Zinc phosphate and Zinc carbonate. It can be used in different types of soils and for all types of crops. It helps plant to utilize Zn fixed in soil.

Liquid formulation of Zn-solubilizing bacteria

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 (kg/ha)
Rhizobium	0.5	Pulse and oilseed crops	Seed treatment	50	20.0	470	19-22 N kg/ha (legumes)
Azotobacter	0.5	Cereal, fodder crops, oilseeds & vegetables	Seed, seedlings & soil treatment	50	18	390	15-20 N kg/ha
Azospirillum	0.5	Cereal and fodder crops	Seed treatment	50	15	320	20 N kg/ha
BGA	1.5	Rice	Direct spray in soil	50	25	550	25-30 N kg/ha
P-solubilizer (PSB)	0.5	All crops	Seed treatment	50	25.0	1250	25 kg P_2O_5/ha
AM inoculant (VAM)	12.50	Horticultural nursery and all other crops	Direct spray in soil	625	25.0	1700	20-30 kg P_2O_5/ha

N/P: Net profit

Year-round cultivation of baby corn through drip irrigation

Baby corn can be produced from both common sweet corn and field corn. However, field corn varieties offer greater economic advantage owing to their lower seed cost. Baby corn cultivation is a highly water intensive enterprise. Matching the water requirement of this crop with water availability is a stupendous task facing the Indian farmers. Baby corn cultivation provides avenues for crop diversification, value addition and increased profitability. Poor germination, scanty rainfall and slow growth in winter season are other limiting factors to quality and early production of baby corn for premium market. Baby corn is a money-making crop and farmers can boost their income in a short period by cultivating this crop. To achieve the objective, they are required to be equipped with the cultivation technology of this crop.

Preparation of field, seed rate and planting density

Plough the field to fine tilth with the help of a tractor by using a mould board plough and a disc plough, a cultivator and a rotavator, and form wide ridges and furrows. Sowing should be done on the side of ridges with 60 cm x 15-20 cm row to row and plant to plant spacing depending upon the plant type (erect/spreading), and in these furrows, 2-3 seeds should be dibbled at each hill. The optimum depth of sowing is 7-8 cm in *kharif* and 4-5 cm in *rabi*. The optimum planting depth for sweet corns is 3-4 cm, while for super sweet corns, it is 2.5 cm.

Preparation of field

The optimum seed rate is 22-25 kg/ha depending upon the test weight of the hybrid. For baby corn, the optimum plant density varies from 1,25,000 to 1,43,000 plants/ha with a spacing pattern of 40 cm x 40 cm or 40 cm x 35 cm (with 2 plants/hill). A total of 83,334 plants can be accommodated in 1 hectare field by adopting 20 cm plant to plant and 60 cm row to row spacing with a seed rate of 22 kg/ ha (HM-4 variety).

Time of sowing

In northern India, it can be sown from February to November. As there is no necessity for pollination and seed setting, this crop can be sown any time round the year under irrigation. But in December-January when temperature is low, it can face the problem of poor germination; therefore a nursery is raised. A nursery of baby corn can be raised under protected structure. For nursery raising, cocopeat, vermiculite, perlite and vermi compost should be mixed in the ratio of 3:2:1:6 and filled in plastic plug-trays, and a single seed in each cavity is sown. The seedlings are ready for transplanting within 20-30 days.

Baby corn under drip irrigation

Generally, August to November planting of baby corn gives the best quality baby corn.

Drip irrigation

Baby corn can be grown year the round (i.e, three crops continuously in a year) under drip irrigation system. The drip irrigation system consists of a head work that includes a hydro-cyclone filter, a sand media filter with a back ? ush mechanism, main lines (PVC pipes of 60 mm diameter with a pressure of 6 kg/cm^2), sub-main lines (PVC pipes of 40 mm diameter with a pressure of 6 kg/cm^2), laterals, drippers, pressure gauges, pressure release valves and flush valves etc. The system ensures a uniform moisture distribution pattern both under surface and sub-surface.

Baby corn under drip irrigation

Fertigation

Farm yard manure (FYM) 12.5 t, nitrogen 150 kg, phosphorous 60 kg, potassium 60 kg and zinc sulphate 25 kg/ha are recommended for baby corn cultivation.

Crop water requirement of baby corn

The water requirement of baby corn ranged from 0.1 to 3.4, 1.2 to 8.2 and 0.6 to 5.5 mm/day from the early stage to the peak demand period during October - February, April - July and August-November, respectively.

Harvesting of baby corn

Crop water requirement during different crop growth stages in different seasons

Year-round cultivation	Crop water requirement (mm)				Total water requirement (mm)
	Initial stage	Developmental	Middle stage	Maturity stage	
1st season (October-February)	(20 days)	stage (30 days)	(30 days)	(34 days)	
	14.5	65.0	57.60	59.10	196.2
2nd season (April-July)	Initial stage (20 days)	Developmental stage (25 days)	Middle stage (15 days)	Maturity stage (13 days)	
	50.5	145.1	46.3	43.6	285.5
3rd season (August-November)	Initial stage (20 days)	Developmental stage (25 days)	Middle stage (15 days)	Maturity stage (11 days)	
	23.4	95.7	28.1	30.8	178.0

Weed control

Broad leaf weeds and most of the grasses can be controlled by pre-emergence spray of Atrazine @ 1.0- 1.5 kg/ha in 500-600 litres of water. One to two hoeings are recommended for aeration and uprooting of the remaining weeds. While doing hoeing, the person should move backward to avoid compaction of soil and to facilitate better aeration.

Plant protection measures

The crop is sprayed with profenophos @ 2 ml/litre at 35 DAS and phorate is applied to avoid the incidence of stem borer. Stem borer (*Chilo partellus*), Pink borer (*Sesamia inferens*) and Sorghum shoot fly (*Atherigona* spp) are serious problems in *kharif, rabi* and spring seasons, respectively. Stem borer can be controlled by 1-2 sprays of carbaryl after 10 and 20 days of germination. Spraying should be done in the central whorl of the plant. The first spray consists of 500 gm carbaryl in 500 litres of water in the central whorl of the plant. The second spray consists of 750 g carbaryl in 700-800 litre water, if required. Additionally, baby corn ears are tightly wrapped inside the husk, which helps protect them from pest attack. Potential disease problems include Stewart's wilt, leaf blight, rust and viruses.

Detasseling

Baby corn is an unfertilized small cob. So to avoid pollination, the removal of male inflorescence soon after its emergence is a very important and crucial operation. The crop should be under close observation for the removal of male inflorescence (tassel) as soon as it emerges from the flag leaf. The removal of tassels is commenced from 47 days onwards and continued till all the tassels have emerged. It should be practiced row-wise. It should be removed in such a way that it should not cause any damage to the plant. The male inflorescence can be fed to cattle, as it is rich in nutrients.

Harvest and storage

Baby corn is hand-harvested 2 to 3 days after silk emergence, while the ears are still immature. The ideal ear size is 5 to 10 cm in length and 0.8 to 1.7 cm in diameter, and the desired colour is golden yellow. After 8 or 10 days of first harvest, second and third cobs will be ready for harvesting. The harvest period can last 2 to 4 weeks. Harvesting period should be within 10 - 12 days for *kharif*/spring crop and 20 days for winter crop.

Yield

The yield depends on the potential of genotypes and climatic conditions. In a good crop, on an average, 5.5-11.4 t/ha husked

Baby corn with husk

Baby corn without husk

Husked and dehusked baby corn

baby corn or 1.1-1.9 t/ha de-husked baby corn can be harvested. Green fodder yield is about 15 - 40 t/ha, which gives additional income to the growers. All the growth parameters and yield of baby corn were recorded highest under biweekly fertigation frequency. The highest yield of cob (13.25 t/ha), baby corn (2.25 t/ha) and fodder (63.33 t/ha) were recorded in biweekly fertigation schedule at a system operating pressure of 1.0 kg /cm^2.

Economic analysis of baby corn cultivation

The benefit-cost ratio of baby corn cultivation for the consecutive three crop seasons in a year was estimated. High values of benefit-cost ratio of 3.04, 3.68 and 1.86 were estimated (if the sale price of baby corn is ₹ 100/kg and green fodder is ₹ 1/kg) under biweekly fertigation for crops grown during October-February, April-July and August-November, respectively. The payback period refers to the recovery period for the amount spent in purchase and installation of drip irrigation system. The minimum payback period (0.58 year) was estimated under biweekly fertigation frequency during April to July. It is recommended that biweekly fertigation will give more yield, good quality produce, higher water use efficiency and good economic return with minimum payback period for baby corn cultivation.

Production technology for *kharif* onion through drip-fertigation

Onion is an important vegetable crop and occupies 1.087 million ha area with a total production of 17.51 million tonnes (2011-12) in India. In north India, onion is cultivated mainly in *rabi* season which is harvested in April-May. The yield of onion varies from 25 to 35 t/ha under irrigated condition in *rabi* season whereas it is only 15-20 t/ha in *kharif* season. Low productivity of *kharif* onion is mainly because of lack of awareness of the farmers about its production technology namely drip fertigation technology. Keeping the above point in mind, a new crop production technology was developed with the objectives of assessing the potential of *kharif* onion in remunerative replacement of rice in water deficit areas of north India.

Raised bed preparation and sowing of crop

Sowing and irrigation system design

Sowing/transplanting was done on raised beds of 90 cm wide having furrows on both sides of each bed during first week of August with row to row and plant to plant spacing of 10 cm x 7.5 cm. Spacing between two laterals was 1.2 m accommodating 10 rows of onions per bed per lateral. Drip system was designed with head works, which included a pump, a sand media filter (flow rate 25 m^3/h and silica sand size 0.7 mm), a disc filter, back flush mechanism and a fertilizer injection system (25.4 mm venturi having 1800 lph injection rate) equipped with two pressure gauges and control valves.

Drip system installed in the crop

Fertigation

To meet the nutritional requirement of onion crop, 160 kg/ha nitrogen (N), 115 kg/ha phosphorous (P_2O_5) and 95 kg/ha potassium (K_2O) were applied throughout the crop season.

Urea, muriate of potash and single super phosphate (SSP), mono potassium phosphate (MKP) were used to supply N, K_2O and P_2O_5, respectively. Thirty per cent (30 %) N, 60 % P_2O_5 and 40 % K_2O were applied as basal dose at the time of sowing of crop. Phosphorous was applied in the form of SSP in basal dose and remaining 40 % was applied in the form of MKP with fertigation. Fertigation was started 21 days after sowing and was stopped 15 days prior to the harvest of crop. During the remaining 68 days of the crop duration, fertigation was done weekly with irrigation in drip fertigation. Total fertigation events in the crop season were 8.

1st stage of onion crop

Irrigation water requirement of crop

The crop duration of onion (90 days) was divided into four stages, namely, initial (1st) 15 days, developmental (2nd) 45 days, middle (3rd) 20 days and maturity (4th) 10 days. The crop water requirements were calculated by multiplying the ETo values with the onion crop coefficients (Kc) as 0.7 for the 1st; 0.90 for the 2nd, 1.0 for the 3rd and 0.75 for the 4th growth stages. Total crop water requirement of *kharif* onion was estimated as 30 cm in drip and 45 cm in flood irrigation considering 90 % and 60 % irrigation efficiencies, respectively.

2nd stage of onion crop

Production, water productivity and fertilizer use efficiency (FUE)

Highest yield of 30.55 t/ha was observed with 34.8 % saving of water and 53.7 % enhance in yield was observed in drip fertigation technology in comparison to flood. The highest water productivity of 10.2 kg/m^3 was obtained under drip fertigation technology with B:C ratio of 1.72 (Income ₹1.75 lakh per ha per year). On the other hand, in conventional irrigation, an average water productivity of 2.8 kg/m^3 was obtained where 33.3 % more irrigation water was applied in comparison to drip. Fertigation with drip irrigation gave proportionally higher FUE (54 %) in comparison to flood.

3rd stage of onion crop

Technology potential

To produce 1 ton of bulb in *kharif* season, amount of nutrients (N, P_2O_5 and K_2O) required were estimated. It was observed that nutrient requirement under flood is almost double in drip with fertigation. Thus, more than 50 % fertilizers can be saved in drip in comparison to flood without reducing the production. *Kharif* onion plays an important role in supply chain management from October to January all over the country. This technology is having enormous potential in terms of nutrients saving besides water saving in the farmers' field.

Harvested onion bulb

Water requirement for onion was estimated as 300 mm while for paddy, it is 1200 mm that is almost 3 times higher than that of onion. Presently, only 2% area is covered by onion during the *kharif* season in comparison of paddy. Distribution of rainfall during the monsoon is quite erratic and more than 80% of irrigation water requirement of paddy is normally met by groundwater pumping. If 25% of paddy growing areas is replaced by *kharif* onion in major paddy growing northern state, more than 50,000 million cubic meter water can be saved therefore, onion can be considered as a potential optional crop for *kharif* season. This technology needs large scale adoption in north India known for rice production for the saving of water. Secondly, farmers may have much profit by growing onion in *kharif* season in place of paddy.

A view of *kharif* onion crop

Engineered Wetland Technology for Wastewater Treatment and Re-Use in Agriculture

Freshwater scarcity, generation of increasing volumes of wastewater, degradation of freshwater resources and the interconnected food insecurity due to rapid urbanization/ industrialization, are driving many countries to use marginal quality water in agriculture. Reuse of sewage wastewater in agriculture is fast becoming popular worldwide because it closes the loop between water demand and wastewater disposal and enhances fertilizer security of resource poor farmers. However, due to the lack of proper treatment facilities and awareness in developing countries, unplanned application of raw sewage is increasing the risks related to agricultural sustainability and consumer/ environmental health. Thus, for safe agricultural disposal, with optimum profit, safe, economic and effective treatment of sewage is one of the most challenging problems faced worldwide. The most common method of sewage treatment in India is the use of oxidation pond or activated sludge process. These processes are expensive and require complex operations and maintenance. Due to improper design, poor maintenance, frequent electricity break downs and lack of technical man power, the facilities constructed to treat wastewater do not function properly and remain closed most of the time.

In view of these limitations, two- engineered wetland technology based wastewater treatment systems involving plants, soil, and native microorganisms that mimic natural physical, biological, and chemical processes of the natural wetlands have been developed by the Institute (IARI) within its campus, and the treated wastewater is being used for agricultural purposes.

System 1: Wastewater Treatment System for Treating Sewage Discharges from Large Sized Communities

Capacity: 2.2 MLD

Design: Horizontal Sub-surface Flow

Sewage source: Krishi Kunj Colony near IARI campus

Land area: 1.42 hectares

Irrigation potential: 132 ha

Components:

A grit chamber; 3-treatment cells (of 80 m x 40 m size); a collection tank (of 80 m x 40 m x 1.5 m size) for holding treated water and a combination of riser and hydrants for diverting treated water into IARI irrigation network.

Each treatment cell is stratified with a 60 cm thick layer of pebbles of varying sizes/ grades, on which *Typha latifolia* is planted.

Treatment efficiency

The system is capable of reducing Biological Oxygen Demand (BOD) from 450 mg/L to 100 mg/L; Total Suspended Solids (TSS) from 220 mg/L to about 2.2 mg/L and heavy metals by 75 to 85 %.

System 2: For Treating Sewage Discharges from Small Sized Communities

Capacity: 1500 LPD

Design: Batch fed Vertical Sub-surface Flow

Sewage source: IARI campus

Land area: 50 sq. meter

Components:

A series of 18 water tanks of 500-litre capacity, connected parallel to a pipe that carries sewage from a sump. The sewage is retained in tanks planted with *Phragmites karka*, *Typha latifolia* and *Acorus calamus* plant species for 14 to 17 hours before releasing it to another *sump*. The treated water is then pumped, as required for its use in adjoining experimental fields.

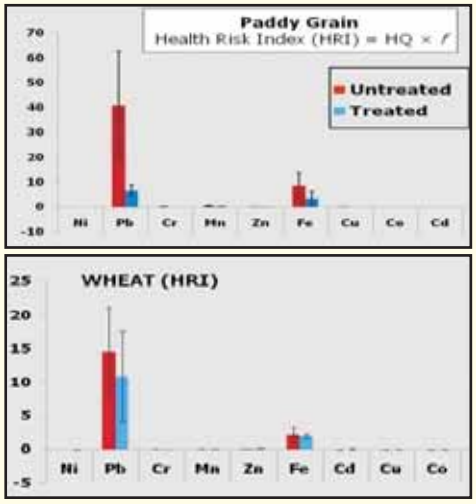
Treatment efficiency

Annual turbidity removal efficiency is 80 to 92% and nutrient/ metal reduction efficiency is 68 to 82%.

Proposed Engineered Wetland Vs. Conventional Sewage Treatment Plants (STP)

In comparison to conventional STPs, engineered wetland technology has been tested to be associated with:

- Just 1% energy requirement
- 50-65% reduced cost of treatment
- No skilled manpower requirement
- Zero-chemical and zero-sludge and
- 1500 times more environmentally sustainable



Impact of Treated Vs. Untreated Sewage Water on Soil Health and Food Grain Contamination

Application of treated wastewater could result in significant reduction in soil total and bio-available lead (Pb) and iron (Fe) concentrations at the sewage plot site. Also, paddy and wheat grains produced from treated wastewater were observed to be associated with 44 to 58% less consumer health hazard due to metal contamination.

Decision Support Systems and Software for Integrated Water Resource Management

The institute has developed several indigenous software, models, decision support systems and information systems for integrated water resource management. All these tools have been extensively tested and validated across varied agro-climatic settings.

IRRIMETHOD- A Software for Selection & Design of Different Methods of Irrigation

The software IRRIMETHOD is developed in Visual Basic (VB) programming language and is capable of selecting and designing most appropriate method of irrigation based on twenty two different parameters and the design details of the system.

USAR – A Decision Support System (DSS) for Managing Salt Affected Agricultural Land & Water

The copyrighted technology for:

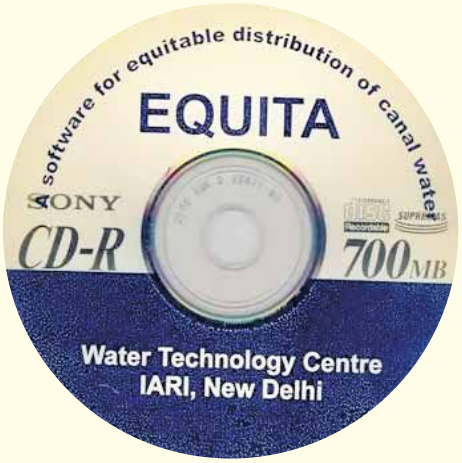
- Quantifying short/long term impacts of a range of geo-hydrologic conditions and resource management plans (viz. conjunctive water use and crop rotation plans) on regional soil-water degradation and agricultural productivity under current and future climatic conditions.
- Proposing appropriate conjunctive water use and crop rotation plans for managing productivity of salt affected agricultural lands.
- Generating crop-specific saline water irrigation schedules for 50 different crop types (ranging from cereals, pulses, and oilseeds to vegetables) and 12 different soil types (ranging from sand/loamy sand soils to silty- clay/ clay soils) in a menu driven environment.

DRIPD : A Software for Designing Drip Irrigation System and FERGON : A Software for Designing Fertigation System

The software provides design details of drip irrigation system and its cost for most crops including fruits, vegetables and closely spaced field crops like onion, garlic etc., under any agro-climatic condition.

EQUITA – A Software for Equitable Distribution of Canal Water

The software provides information on rostering of canal water supply from the outlet of a distributary in a canal command to different farm holding sizes.



ResourCeS – A Regional Resource Characterizing Spatial Decision Support System

The copyrighted technology for:

- Assessing actual water use, water productivity and soil, water and vegetation health, delineating actual extent of canal command areas.
- Benchmarking and assessing canal irrigation performance.
- Delineating areas with potential for conjunctive use of canal and ground water.

Img2Info© : A Novel Software for processing Aircraft/ Satellite based Remote Sensing Data

The copyrighted technology for:

- Field soil moisture content estimation for scheduling large area sowing operations.
- Accurate winter crop discrimination.
- Soil productivity factor quantification.
- Generating accurate land use and soil maps.

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.

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.

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

Laser leveler machine

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

Laser land leveling

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.

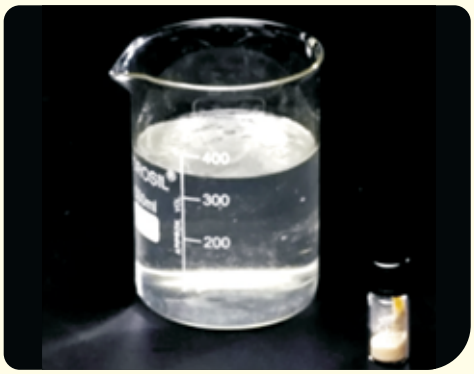
Aqua-Fertilization Technology (Aqua-Ferti-Seed Drill) for dry lands

- 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.

Enhanced Water Use Efficiency

Pusa Hydrogel

Suitably designed and developed super absorbent polymers commonly termed as hydrogels offer an innovative solution in agriculture. These materials possess ability not only to absorb and retain water many times their dry weight, but also gradually release the same in *rhizosphere* zone. Besides agricultural applications, this product finds its utility in house hold gardening also. Commercially available hydrogels usually suffers from disadvantages like collapsing of gel structure at temperature above 30 °C, failure to absorb water in presence of fertilizer and very high recommended rates of application. Research endeavors at Division of Agricultural Chemicals, IARI, led to development of Pusa Hydrogel a novel super-absorbent cellulosic hydrogel that absorbs a minimum of 350 times its weight of pure water even at 50 °C. This product is designed and developed specially to perform in the tropical and sub-tropical conditions of India.



Advantages

- Based on natural polymer
- Exhibits enhanced water absorbency (350 times)
- Improves physical properties of soils
- Improves seed germination and seedling emergence
- Helps plants withstand extended moisture stress
- Reduces irrigation and fertigation requirement
- Reduces leaching of herbicides and fertilizers
- Efficient even at high temperatures (40-50 ^{O}C)
- Higher cost benefit ratio
- Effective in soil for a minimum period of crop season

Application dose: 1-1.5 kg/ acre

Application method: Soil mixing, seed coating, cutting coating, root drench, cutting drench etc.

Availability: Available in market with trade name Kauveri® and Varidhar®

Neem-products

Neem coated urea for enhanced N- use efficiency

- 7-17% yield increase in rice

Azadirachtin Concentrate (20-25%) Effective @ 300 ppm against

- *Atherogonia soccata* on maize, wheat, and barley
- *Plutella xylostella* on cabbage
- *Lipaphis erysimi* on rapeseed
- *Helicoverpa armigera* on sorghum and chickpea
- *Bemisia tabaci* on soybean and tobbaco

Neem Formulations – EC, SL and CRF

Effective in protecting maize, mustard, cabbage, sorghum, moong, cowpea, pigeon pea and tobacco for a range of pests

Reduced Aza-A Concentrate and Formulations

- Thermo- and photo stable product
- Effective against *Helicoverpa armigera*

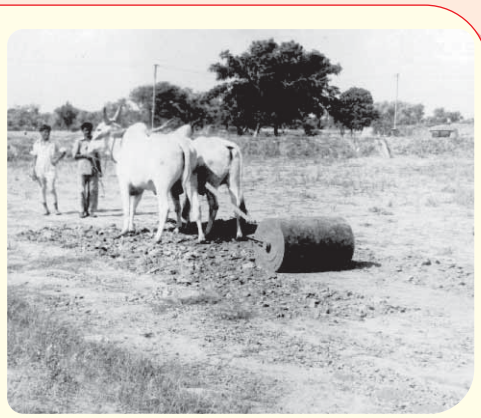
Agricultural Physics Based Technologies

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.

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.



Bullock driven roller

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.

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.

De-branched plot of mustard

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.

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 in both print and electronic media. The weekly agro-met advisory bulletins are provided to the farmers on real time basis. A weather related web page has been developed and being maintained at IARI website (www.iari.res.in/*dainik mausam aur krishak sewa*). Weather related information is provided frequently in newspapers (*Dainik Jagaran* and *Aaj Samachar*). These weather forecast agro-advisories have been helping farmers in taking tactical farm decisions related to crop management.

Weather based agromet advisories in service of the farming community

White rust disease incidence forewarning model

Thumb rule for incidence of white rust disease was developed for mustard crop.

If sum of hours in consecutive 10 days with

a) temperature ranging from 10 to 20 ^{o}C is more than 150

b) relative humidity more than 80 per cent is more than180 and

c) actual bright sunshine hours is less than 10 then, it is quite likely that the white rust disease would appear in the mustard. or If there are rainy days during December and January along with the total sunshine hours of past 10 days less than 40, then the white rust disease would appear.

Prediction of *Spodoptera litura* in ground nut crop

The congenial weather parameters for attack of *Spodoptera litura* have been identified from the historical data of the pest in ground nut crop. These were–weekly mean maximum temperature (25-28 ^{o}C), minimum temperature (> 19.5 ^{o}C), morning relative humidity (> 90 %), evening relative humidity (78-83 %) and total rainfall (< 20 mm).

Spodoptera litura

Aphid prediction rule for mustard

The rule includes crop phenology, weekly mean maximum and minimum temperatures and cloudiness to forecast the early appearance (December-mid January) of mustard aphid.

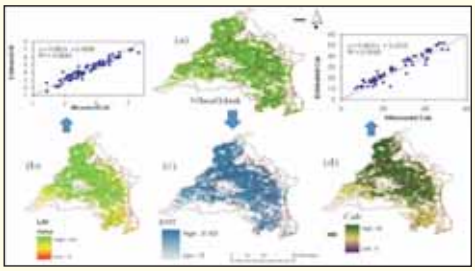
- Crop phenology: 100% flowering
- Weekly mean max. temperature >20 ^{O}C
- Weekly mean min. temperature >8 ^{O}C
- Cloudiness (2-3 days in the week) or
- If weekly mean maximum temperature increases above 30 ^{O}C, aphid population decreases rapidly. Cloudiness and drizzle may enhance the population, but it decreases substantially, if rainfall intensity is high >20mm/day or 10 mm/hr).

Mustard aphids

Remote Sensing based Technologies

Monitoring crop growth condition for site specific management

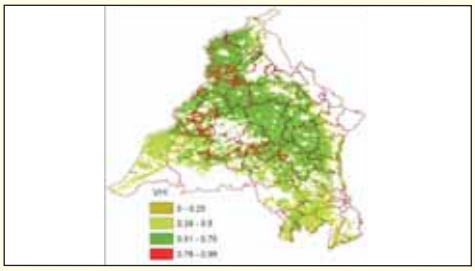
Improved physical model based technique for quantitative assessment of plant biophysical parameters from remote sensing and there by monitoring crop health at regional scale. The methodology used the radiative transfer model, PROSAIL for retrieval of leaf area index (LAI), chlorophyll (Cab) and water content (Cw) of wheat crop in Trans-Gangetic Plains through its inversion. The method was evaluated and found better than existing empirical approaches. The parameters thus derived were composited to develop a vegetation health index (VHI) which can be used for monitoring crop growth condition at regional scale for site specific management.



Biophysical parameters of wheat crop of Trans-Gangetic Plains of India from remote sensing data through radiative transfer modeling

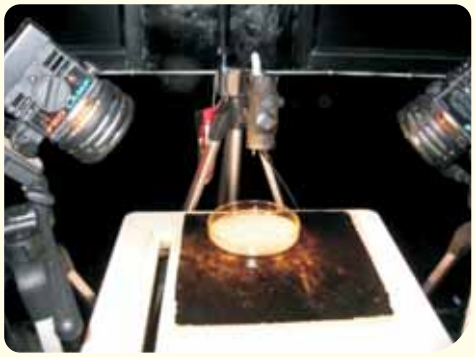
Methodology for measurement of site fertility parameters

Developed methodology for non-destructive *in situ* measurement of soil fertility parameters and upscaled to regional level for soil fertility mapping from hyperspectral remote sensing data. A method was developed to retrieve different soil parameters from suitable spectral bands using hyperspectral sensors both at ground (spectroradiometer) and satellite platforms (Hyperion sensor of EO-I satellite). This was developed initially for part of Jalandhar district of Punjab, later on upscaled to regional level.



A composite vegetation health index developed from retrieved plant parameters

Weather based agro-advisories



Soil Sensing using hyperspectral sensors for retrieving soil parameters

7

Plant Protection Technology

Helicoverpa on cotton boll

Safe spraying of pesticide

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 and their management

Insect-pests	Management

Rice

Stem borer: Three species of stem borer (yellow stem borer, pink stem borer and white stem borer) damage rice crop in north India. The larvae of this insect enter plant base and cut the central whorl of leaf, that subsequently dries and turns brownish. This symptom is called 'dead heart'. When plants are attacked at panicle initiation stage, larval feeding results in drying of panicles, which are termed as 'white ears'. The 'dead hearts' or 'white ears' can be easily pulled from the plant. These insects attack the plants from tillering stage to maturity with peak infestation 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.
- Use light traps to monitor and mass trap moths of stem borers.
- Avoid excessive use of nitrogenous fertilizers.
- Remove tips of seedlings before transplanting.

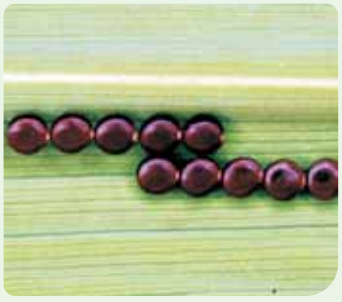
Stem borer

- Collect and destroy dead hearts and white ears.
- After 30 days of transplanting, release *Trichogramma japonicum* @1,00,000-1,50,000/ha/week for 2-6 weeks.
- Install pheromone trap (Scirpolure) @ 5/ha for monitoring and 25/ha for mass trapping of yellow stem borer.
- Harvest the crop near to ground level and destroy crop stubbles.
- 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 @ 2ml/L of water or cartap hydrochloride 50 SP @ 1ml/L of water or chlorantraniliprole (Coragen) 18.5 SC@ 1 ml/3L of water or acephate 75 SP @ 1.5 g/L of water.

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 turn brownish and dry. In case of severe infestation, circular patches of dried crop are seen which are termed as 'hopper burn'. Maximum infestation of BPH is observed during September and October.	• ETL: 10 hoppers/hill. • 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, or thiamethoxam 25 WG 1 g/5L or fenobucarb (BPMC) 50 EC @ 1 ml/L or buprofezin 25 EC @ 2 ml/L water or ethiprole (40%) + imidacloprid (40%) SG @ 1g/4L water or DDVP 76 EC @ 2ml/L water. • Nozzle should be directed towards plant stems while spraying.
Leaf folder: The leaf folder larva folds leaves by fastening their margins and feeds on chlorophyll as a result of which transparent streaks are formed. Peak infestation is witnessed from mid August to end of September. During severer damage by this pest whitish plant tips are visible from a distance.	• ETL: 2 damaged leaves/hill. • Use light traps. • Avoid excessive use of nitrogenous fertilizers. • Release *Trichogramma chilonis* @ 1,00,000-1,50,000/ ha/week for 2-6 weeks after transplanting. • Conserve predators like rove beetle.
***Gundhi* bug:** The insect produces characteristic unpleasant smell in field. The adults and nymphs suck the milk from the developing grains. Infestation is characterized by the presence of some empty or partly filled grains having black spot at the point of puncture.	• Need based application of cartap hydrochloride 4G @ 25 kg/ha or spray of quinalphos 25 EC @ 2 ml/L or chlorpyriphos 20 EC @ 2.5 ml/L or flubendiamide 39.35 SC @ 1 ml/8L or cartap hydrochloride 50 SP @ 1.5 g/L or acephate 75 SP 1.5 g/L water or chlorantraniliprole (Coragen) 18.5 SC @ 1 ml/3L water. • ETL : one bug per plant. • Practice synchronous planting in an area. • Remove *Echinochloa* weed. • Depending upon need, apply carbaryl 50 WP 2 g/L water or 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

Maize

Insect-pests	Management
Spotted stem borer: The first indication of stem borer infestation is the appearance of small elongated windows or round holes on the young maize leaves in 2 to 3 weeks old crop due to feeding by the young stem borer larvae. The third instar larvae migrate to the base of the plant, bore into the shoot, and damage the growing point resulting in the production of deadheart.	• Collecting and burning of stubbles, and feeding the stalks to cattle before the onset of monsoon rains reduces the carryover of stem borer. • Plant maize varieties with less susceptibility to stem borer. • Carbofuran 3G or Phorate 10G can be applied in the whorl leaves of maize plants @ 20kg/ha and 8kg/ha respectively to reduce stem borer damage. • The spotted stem borer can also be managed by use of egg parasitoid, *Trichogramma chilonis* @ 8 Trichocards/ha at 10 days after germination.
Pink borer: Newly hatched larvae remain behind the leaf sheath and begin chewing on the stem and inner side of the sheath. If larvae invade the whorl, unfolding leaves are chewed resulting in topping of the central whorl.	 Small-elongated window holes by spotted stem borer
 Pink borer damage	• Collecting and burning of stubbles, and feeding the stalks to cattle before the onset of monsoon rains reduces the carryover of stem borer. • Plant maize varieties with less susceptibility to stem borer. • Carbofuran 3G or Phorate 10G can be applied in the whorl leaves of maize plants @ 20kg/ha and 8kg/ha respectively to reduce stem borer damage.

Insect-pests	Management
Shoot fly: Shoot fly females lay cigar shaped eggs singly on the lower surface of the leaves at the 1 to 7 leaf stage. The larva cuts the growing point, resulting in wilting and drying of the central leaf known as "deadheart".	• Spring sowing must be accompanied with seed treatment with imidacloprid @ 6ml/kg seed for shoot fly control.
	 Shoot fly deadheart
Termites: The termite infestation at the seedling stage shows wilting symptoms in the young seedlings, and on complete damage to the root system result in irreversible drying of the plants. In older plants, termites begin to attack the main root system, prop roots, stems, cobs, and eventually pack the stems with soil and cover them with galleries or tunnels made of thin sheets of soil.	• Remove the maize crop stubbles and deep summer ploughing to reduce termite menace in the forthcoming crop season. Clean cultivation delays termite attack. • Application of fipronil granules @ 20 kg/ha followed by light irrigation is useful for termite control.
 Termite sand galleries on maize cobs and stems	

Insect-pests	Management

Gram pod borer: It is the most important insect pest of chickpea, pigeonpea and other pulse crop. Young larvae feed voraciously on tender leaflets, developing buds, flowers while matured larvae bore into the pods and feed the grains. Damaged pods show a circular bore hole. Half portion of larva remaining outside the damaged pod while feeding is an important characteristic of *Helicoverpa*. High population can be seen from bud formation to pod maturity stage.

Spotted pod borer: Larva of this pest is whitish to pale green in colour with dark spots on the dorsal surface of the body. Young larvae bore into flower buds and cause flower shedding while older ones bore into maturing pods. Webbing of tender leaves, flower buds and pods together characterizes the damage of Maruca. Flower bud stage is the most preferred stage for oviposition. Single larva consumes 4-6 flowers during its development. Seeds in the damaged pods are totally or partially eaten out by the larvae.

Maruca larva

Webbing due to Maruca infestati in pigeonpea

- Deep summer ploughing for exposing and destroying pupae of the pest.
- Install pheromone traps @ 5 per ha to monitor the moths.
- Erection of bird perches
- Spray *Ha*NPV 250 LE @ 1 ml/L water or *Bt* @ 1g/L or NSKE 5% or neem oil 3000 ppm @ 20 ml/L.
- Spray emamectin benzoate 5 SG @1ml/2L or flubendiamide 39.35 SC@ 1ml/5L or profenofos 50 EC @ 2 ml/L or indoxacarb 14.5 SC @1ml/L or spinosad 45 SC @ 1ml/4L chlorantraniliprole 18.5% SC @1ml/4L of water.

Helicoverpa on damaged pigeonpea pod

Pod borer larvae on chickpea

- Spray emamectin benzoate 5 SG @1ml/2L or flubendiamide 39.35 SC@ 1ml/5L or profenofos 50 EC @ 2 ml/L or indoxacarb 14.5 SC @1ml/L or Spinosad 45 SC @ 1ml/4L chlorantraniliprole 18.5% SC @1ml/4L of water.

Insect-pests	Management
Pod fly: This is another important insect pest of arhar common in north and central India. Adult fly lays eggs individually in the developing pods and white maggots bore inside the pod and feed on the developing grains. Small holes are seen on pods when matured maggot is about to pupate. Pupation takes place within pod itself and adult fly emerges from the pod by making a pin sized hole. Tunneling type of feeding on seeds is the indication of pod fly damage. The concealed feeding habit thus causes more loss to the crop as management measures cannot be taken.	• Spray lambda-cyhalothrin 5EC @1ml/L or flubendiamide 39.35SC@ 1ml/5L or indoxacarb 14.5 SC @ 1ml/L or quinalphos 25EC @ 2ml/L or monocrotophos 36 SL @ 2 ml/L of water.
	 Podfly maggot and puparia in the damaged pigeonpea pod
Blister beetles: Blister beetles are flower feeders and reduce the number of pod setting thereby affecting the crop yield. Adults are black beetles with bright orange-red colouration across the abdomen. They are seen individually or in groups at the terminal portion of the plant during crop flowering stage.	• Picking and dipping the adults in kerosenized water. • Spray indoxacarb 14.5 SC @ 1ml/L or acephate 75 SP @ 1.5 g/L or carbaryl 50 WP @ 2 g/L of water.
 Blister beetle feeding on pigeonpea floral buds	

Insect-pests	Management
Pod bugs: Both adults and nymphs suck the cell sap from leaves, flowers, stem and pods. Damaged pods show yellowish to brownish patches and the grains in the pods become smaller in size and shriveled appearance.	• Spray monocrotophos 36 SL @ 2 ml/L or triazophos 40 EC @ 1.5 ml/L of water.
	 Riptortus bug
Whitefly: Nymphs and adults suck the cell sap from leaves, flowers and developing pods. The infested plants become very weak and show crinkling and downward cupping of leaves. Secretion of honey dew attracts sooty mould development which in turn affects the photosynthesis. Whitefly is also a vector of number of viral diseases especially mungbean yellow mosaic virus (MYMV).	• Rogue out MYMV affected plants at early crop growth stage and bury them. • Set up of yellow sticky trap to reduce the incidence of white fly. • Seed treatment with dimethoate 30 EC @ 5 ml/kg seed or imidacloprid 17.8 SL @ 3 ml/kg seed is effective. • Spray imidacloprid 17.8 SL @ 0.3 ml/L or acephate 75 SP @ 1 g/L or triazophos 40 EC @ 1 ml/L of water to reduce the incidence of whitefly population and MYMV.
 MYMV infected green gram	
 Whitefly	

Insect-pests	Management

Mustard

Aphids: Both nymphs and adults suck cell sap from leaves, stems, inflorescence or the developing pods. The vitality of plants is greatly reduced due to very high population of the pest. 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.
- Removal of infested shoots manually at early stages.
- Spray contact or systemic insecticides when the ETL of 15-20 aphids/10 cm long inflorescence shoot is reached.
- Foliar spray of oxydemeton methyl 25EC, dimethoate 30EC, 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. Spray malathion 50 EC @ 500 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 of 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 period; the early stage of crop growth (up to 7-10 days after germination) is the 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 clinging on 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 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 and 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 triazophos 40 EC 1-1.5L/ha, thiamethoxam 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.	 Red cotton bug
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.	 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 for 10 minutes and wash the seed thoroughly with water.	 Pink boll worm
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.	• ETL: 8 adults per trap for 3 continuous days. • 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 or larva/plant or 5-10% affected bolls.	 American boll worm

Insect-pests	Management

Spotted boll worm: The forewings 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/ plant.

- Erect bird perches to enhance the activity of insectivorous birds.
- Treat the seed with imidacloprid @ 7.5 g/kg seed.
- Utilize 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 *Ha*NPV @ 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 and their management

Insect-pests	Management

Brinjal

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.

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

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 beetle 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/10L) or spinosad (2 ml/10L) at 10-15 days interval against fruit borer alternately.
- Avoid repeated use of same insecticides.

Fruit borer

Leaf hoppers

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 or thiamethoxam (5 g/kg).
- After 35 days of germination, undertake need-based one spray of either acetamiprid (2 g/10L) or imidacloprid (2 ml/10 L) for sucking pests and 1-2 sprays of either spinosad (2 ml/10 L) or emamectin benzoate (2 g/10 L) or cypermethrin (4 ml/10L) against fruit borer in rotation at 15 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 leaves and later instars feed externally on the leaves and also damage curd.	• 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.	 Cabbage aphids
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. • Release parasitoid Apanteles adults @ 1000 adults/ha for control of DBM. • Intercropping of either fenu-greek or *berseem* or coriander increases the activity of predators.	 DBM larval
Tobacco caterpillar: The caterpillars damage seedlings and plants by feeding on leaves during night.	• Spray thiamethoxam (2g/10L) 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.	 Cabbage butterfly

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 (2 ml/10L) or chlorantraniliprole (2 ml/10L) or emamectin benzoate (2 g/10 L). • Repeat spray at 10-15

Tobacco caterpillar

Tomato

Fruit borer: First instar larvae of fruit borer scrape 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 and leaf miner population. • Spray thiamethoxam (2g/10L) 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. • At flowering and fruit stages, undertake 1-2 sprays of methyl demeton (2 ml/L) or spinosad (2-3 ml/10L) or deltamethrin (1 ml/L) against fruit borer in rotation at 15 days interval. • Spray Ha NPV @ 250 LE/ha.
White fly: Both adult and nymph feed on leaves by sucking cell sap. They transmit viral disease.	

Tomato fruit borer

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 used for the fruit flies infesting mango, guava, sapota, and bread fruit and cuelure for cucurbits.

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. Tiny young 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 characteristic to 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 usually occurs at the superficial layer of the grain. Under abnormal conditions, larvae can survive without food for a 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 tiny flying yellowish brown adults, dull appearance of the grain covered by scales of adults and grains with holes with wavy margin.

Rice weevil

Lesser grain borer

Khapra beetle

Red flour beetle

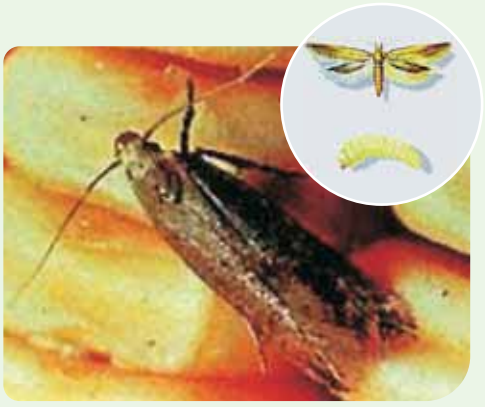
Almond moth *(Cadra cautella)* : Almond moth mainly infests wheat, dry fruits, barley, etc. Larvae feed on stored produce, eating germ point only. Larvae spin silk profusely and at maturity they form small silken tubes among the food particles. After 4-5 days adult comes out.

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 absorbence bed" to dry the grain. This bed is made up of double layered (250 µm) 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 "storage structures", *viz.*, Pusa Bin, Pusa *Kothar*, Pusa Cubicle.
- 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 with exposure period of 5-7 days.

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 head stage. Symptoms appear on leaves, nodes, rachis, and glumes. On 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 seed/@ 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 in water.
- Use dhaincha, sunhemp as green manure and judicious use of area (N) when required.

Diseases & their symptoms

False smut: A sporadic fungal disease. Caused by *Ustilaginoidea 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 after 1-2 weeks of 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.

Management

- 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) @ 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 in water.

Bacterial blight

False smut

Diseases & their symptoms

Bakanae: The typical symptoms of bakanae are slender, chlorotic and abnormally elongated primary leaves, however, not all infected seedlings show these symptoms, as crown rot is also seen, resulting in stunted rice plants. In crops reaching maturity infected plants show tall lanky tillers bearing pale green flag leaves which are conspicuous above the general level of the crop. Infected plants usually have small numbers of tillers and leaves dry up one after another from below and die in few weeks. Occasionally infected plants survive until maturity but bear empty panicles. A white or pink mycelial growth may be noticed in lower parts of the infected plants.

Bakanae disease of rice

Management

- Clean seeds should be used to minimize the occurrence of the disease. Buy seeds from accredited seed growers or reliable sources.
- Salt water can be used to separate lightweight, infected seeds from seed lots and thereby reduce seed borne inoculum.
- Hot water treatment is effective. Soak the seeds in tap water for three hours. Then, soak them again in hot water 50-57 °C for 15 minutes to kill the fungus in seeds.
- Seed treatment with fungicides is recommended. Soak the seeds for five hours in 0.1% carbendazim solution in water. After treating the seeds, drain the fungicide solution, replace with water and soak the seeds for 24 hours before seeding. Seed treatment using fungicides such as thiram, thiophanate-methyl, or benomyl is also effective before planting.
- Practice field sanitation. Remove the rice stubbles, volunteer plants, and weeds after harvesting.
- Rouge or immediately pull bakanae infected plants to avoid contaminating other plants.

Diseases & their symptoms	Management

Wheat

Stem rust: is caused by *Puccinia graminis tritici*. 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 pustules (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.

- 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

Leaf rust: Caused by *Puccinia triticina* and symptoms are oval, brown spots on leaves. Teliospores are produced in the same pustule. The color of the pustule changes from rust color to black as teliospore production progresses. If a large number of pustules are produced, stems become weakened and lodge.

Yellow rust or stripe rust: is caused by *Puccinia Striiformis tritici*. The Symptoms on leaf appear as yellow colored stripes of pustules running along veins of leaf. These also appear on ear head, stem and leaf sheath. The disease is continuously appearing for the last 4-5 years in districts of Punjab and Haryana.

- 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 propiconazole (Tilt 25 EC) 0.1% on leaves once or twice.

Leaf blight: Reddish brown/dark 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.

- 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.

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.

- 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

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. 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.

- Soak the seed in water for four hours and after that place 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.
- Propiconazole @ 0.1% can be sprayed on leaves at boot leaf stage.
- Seed treatment with thiram @ 3 g/kg seed.

Karnal bunt

Flag smut: The symptoms 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.

- Seed treatmment with of carboxin (Vitavax 75 WP) @ 2.5 g/kg.
- Avoid water stagnation in field and irrigation by sprinkler system.

Hill bunt: Symptom appears on tillers in which instead of grains, smut appears. Bad smell comes from infected tillers.

Hill bunt

- Treat the seeds with sulphur or carboxin @ 2 g/kg seed.
- Grow resistant varieties like Pusa 44 and WG 377, VL 738, HS 277, HD 2189, HD 2687, HD 2733 etc.
- Treat the seed with carboxin or thiram or carbendazim @ 2.5gm/kg seed.
- Use disease free seed only.
- Grow resistant varieties like PDW 237, Raj 1555, WH 896 etc.
- Spray the crop with mancozeb or zineb 1.5 kg/ha.
- At boot leaf stage spray 0.1% propiconazole on leaves.

Chickpea

Diseases & their symptoms	Management
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 case of adult plants, drooping of leaves is observed initially in the upper part of the plant, and soon observed in entire plant. Advanced stages of the disease cause complete drying of the plant. Vascular browning is conspicuously seen when roots are split open vertically.	• Treat the seeds with Carbendazim or Thiram @ 2 g/kg or Carbendazim 1 g + Thiram 1 g/kg seeds. • Treat the seeds with the formulation of *Trichoderma viride* or *T. harzianum* @ 4 g/kg or *Pseudonomas fluorescens* @ 6 g/kg of seed. Apply heavy doses of organic manure or green manure. Grow resistant cultivars like Pusa 212, JG 315, GPF 2, KWR 108, GNG 469, Rajas, Haryana chana 3, and GCP 107.
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. • Grow resistant cultivars like PBG5, GNG 1365, H99-9 and Haryana chana-1
	 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. • Grow resistant cultivars like GNG 469, PGB 1, Pusa 413, Pusa 408, H00-108, GL 92024 and Himanchal chana 1. • Spray with Carbendazim @ 500 g/ha or chlorothalonil 1kg/ha. Follow crop rotation with cereals.
	 Blight

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.

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 Carbendazim+ Thiram (1:1) @ 2g/kg seed or formulation of *Trichoderma harzianum* or *Trichoderma viride* @ 4g/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 as Maruti, Malviya arhar 2, Jawahar, and Narendra arhar etc.
- Treat the seeds with Metalaxyl @ 6 g/kg. Spray Metalaxyl @ 500 g/ha or treat the seeds with Apron @ 4 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.

- Timely sowing of certified seed.
- Treat the seeds with thiamethoxam @ 4g/kg seed+ Carbendazim @1g/kg seed+ Thiram @ 1g/kg seed.
- Tolerant and resistant varieties only in affected areas, rouging of weeds.
- Foliar spray of thiamethoxam @ 0.02% + Carbendazim @ 0.05% at 21 and 35 days after sowing. This will be effective for leaf spots also.
- 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.	• Seed treatment and foliar spray as for green gram. • 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. · Seed treatment as for YMV.
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. **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.	• 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 • Remove and burn infected plant debris. Spray Mancozeb @ 2 kg/ha or Carbendazim @ 500 g/ha or Chlorothalonil @2 kg/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 with in plant soyabean and beans. • Completely remove plant residue by cleanly ploughing the field soon after harvest. • Destroy previous years infected stubble. • Treat the seed with Thiram + Carbendazim (1:1) @ 2.5 g/kg seeds.

Pea

Disease and pathogen	Symptoms	Treatments
Wilt **Pathogen:** *Fusarium oxysporum* f.sp. *pisi*	Yellowing of lower leaves of the plant. Stunted plant growth. Vascular system appear as light yellow, orange, brown to black colour after splitting the lower stem. The plants droop off and at last die.	• Sow the crop after 15th November. • Maintain drainage in the field. • Use balanced fertilizers. • Treat the seeds with carbendazim @ 0.5 g/kg seeds. • Follow 2-3 years crop rotations and exclude boardbeans, Vicia and Lathyrus crops.
Rust **Pathogen:** *Uromyces fabae*	Yellow spots having aecia in round or elongated clusters appear on the leaves. The uredinia pustules develop on both surfaces of the leaves and other parts of the plant. The teleuto sori present a powdery, light brown appearance and later almost black in colour.	• Remove infected plant debris from the field and destroy them. • Follow 2-3 years crop rotation and exclude boardbeans, Vicia and Lathyrus crops. • Spray mancozeb, triadimefon, tridemark fungicides on the crops as per requirements.
Downy mildew **Pathogen:** *Peronospora pisi*	Round or elongated, yellow to brown spots appear on the upper surface of the leaves, stipules, petioles and stems. Under cool and moist weather, corresponding under surface of leaves, white to grayish violet downy growth fungus cover. Stunting and distortion of the plants. On pods, elliptical, pale green patches appear which later turn brown.	• Remove infected plant debris fron the field. • Follow 2-3 years crop rotations and exclude broadbeans, Vicia and Lathyrus crops. • Use disease free and certified seeds for sowing. • Maintain drainage in the field. • Deep ploughing of the field in the summer. • Treat seeds with apron 4g/kg seeds. • Spray mancozeb or ridomyl MZ-72@2.5 g/L of water on the crops.
Powdery mildew **Pathogen:** *Erysiphe pisi*	Initially small, diffused, off-coloured spots appear on the upper surface of the lowest leaves. Later, these lesions appear as white, powdery areas, and severely infected foliage looks blue white floury appearance. Tissue beneath these infected areas may turn purplish, after which small, black prithecia are formed in the mature lesions.	• Remove infected plant debris from the field. • Grow resistant variety as Rachna, Pea Pant-4, Aparna. • Dust sulphur powder 25-30 kg/ha or spray karathane 0.6 ml/liter of water on the crops.

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.

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.

Black spot: Light brown spots appear on leaves. The infected leaves become yellow and fall down when mature.

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.

- Treat seeds with hot water at 50°C for 10-15 min. by dipping.
- Spray Streptocyclin (5 g) and Blitox (20 g) per 10 litre of water after transplantation and after an interval of 20 days as per requirement.
- Use healthy and certified seeds for sowing.
- Follow 2-3 years crop rotations.
- Spray Bavistin (1 g /L) or Dithane M-45 (2.0 g/L) from the appearance of disease and @ 15 days interval based on necessity.

Sclerotinia rot

- Treat the seed with Thiram @ 2.5 g/kg seeds or spray with mancozeb @ 2.5g/L of water after appearance of disease at 15 days interval as needed.
- Treat seeds with ridomil at 2.5g/kg seeds.
- Spray Ridomil MZ-72 (3 g/L) after 30 days of sowing and at an interval of 15 days, if necessary.
- Remove diseased plant debris from the field.

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. Infection also occurs on 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.

- Use healthy and certified seeds for sowing.
- Dip the plant roots for 20 minutes in water solution of Bavistin 50 WP (½ g/L) and spray 3 weeks after transplanting or as per requirement.
- Deep ploughing the field n the summer.
- Follow the crop rotation of at least 2-3 years.
- Avoid growing sweet potato and tomato near the brinjal crop.

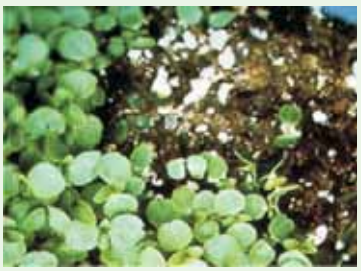
Phomopsis blight

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.

- Dip the seeds in suspension of Blitox-SD @ 2.5g/L of water for 5 min.
- Spray Captan or Blitox (2.5 g/L), treat the seeds and seedlings with *Trichoderma harzianum* @ 4 g/ L.
- Burn nursery beds by using rice straw or dry one week before sowing.
- Prepare raised beds and maintain proper drainage.



Damping off

Bacterial wilt of tomato, brinjal and chilli: Plant initially shows a reduction in the firmness of young leaves and drooping. Sudden wilt of plant within 4-6 days after infection and develop the plant wilt. Excess roots may develop along the stem at low temperature. Brown discolouration of the vascular tissue as well as bacterial ooze may be present.

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.

- Remove infected plant debris from the field.
- Follow 2-3 years crop rotations.
- Dip the seedling in 0.02% concentration of streptocyline for 30 min.
- Apply bleaching powder 12-15 kg/ha in the furrow.
- Remove diseased plants from field.
- Spray Confidor 200 SL (100 ml/500 L) or malathion 50 EC or Rogor 30 EC, 3 weeks after transplanting and at 15 days interval thereafter, 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.

- Remove diseased plant debris from the field.
- 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.	• Use of healthy and certified seeds. • Remove disease plants from the field. • Spray Confidor 200 SL (2 ml/10L) 20 days after transplanting and at 15 days interval, if necessary.

Fruit rot

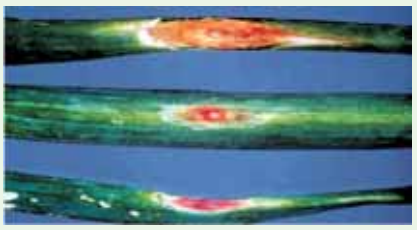
Leaf curl

Onion and Garlic

Purple blotch: Small white sunken spots developed on the leaves, enlarge and become zonate and under moist condition, then 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.

Black mould rot: Black mould occurs on both onions and garlic. Fungus develops between onions and garlic. Fungus develops between dry, dead outer scales and the first inner fleshy scales of the bulb. Invaded scales become water soaked and later diseased scales dry and shrunk and black margin of fungal spores viable between outer scales.

- Remove diseased plants from the field and destroy them.
- Maintain proper drainage in the field.
- Spray Indofil M-45 or Blitox 50 (2 g/L) at 10 days interval, if necessary.
- Avoid injury during harvesting, transportation and storage.
- Spray fungicide like Diathane-M at 2.5 g/L or Blitox-50 at 3.0 g/L before harvesting the crop.



Purple blotch

Ginger

Rhizome 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. Root infection at later stage. 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.

Bacterial Wilt: Infection starts as mentioned in soft rot. Drooping and curling of leaf margins of the lower leaves. Infected plants exhibit yellowing and wilting symptoms. Dark streak appear in vascular tissues. Milky bacterial ooze comes out from rhizome and pseudostem.

- Spray Ridomil MZ-72 (3 g/L) after plant emergence and at 15 days interval, if necessary.
- Seed rhizome treated with Streptocycline at 200ppm for 30 minutes.
- Drenching the plant with Copper oxychloride @ 0.02% suspension.

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.	• Follow 2-3 years crop rotation • Remove infected plant debris from the field and destroy. • Spray Indofil M-45 (2 g/L water) 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.	• Follow 3 years crop rotation. • Spray Ridomil MZ-72 (2g/L) after the appearance of disease and at 10 days interval, if necessary. • Use balanced fertilizers.
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.	• Rouging of infected plants from the field. • Spray Confidor 200SL (100 ml/ 500 L) per hectare after 30 days of sowing, and second spray after 50 days interval, if necessary.
Bacterial wilt or Brown Rot: Wilting, stunting and yellowing of the foliage. The browning of vascular bundles appears in the tuber. Bacterial ooze emerges from the eyes and stem end attachment of infected tubers. Pus like slime coming out from the vascular ring with slight squeezing. Brown discolouration of the vascular ring of the tuber.	• Use healthy and certified tubers. • Remove infected plant debris including tubers from field and destroy. • Follow 2-3 years crop rotation. • Dip the seed tubers in 0.02% of Streptocycline for 30 min. • Apply bleaching powder at 12-15 Kg/ha in the furrow during sowing.

Cucurbits

Disease and pathogen	Symptoms	Treatments
Powdery Mildew **Pathogen:** *Erysiphe cichoracearum* and *Sphaerotheca fulginea*	White, powdery fungal growth develops on leaf surfaces, petioles and stems. Yellow spots may form on upper leaf surfaces opposite powdery mildew colonies. Older plants are affected first. Infected leaves usually wither and die. Plants may senescence prematurely. Fruit infection occurs rarely on watermelon and cucumber.	• Spray Karathane (0.06%), Sulfex (0.2%) or Calixin (0.1%) on the crops at 10 – 15 days intervals.
Downy Mildew **Pathogen:** *Pseudoperonospora cubensis*	Angular, yellow spots on the upper leaf surface. Spots bounded by the leaf veins. Under humid weather, a grayish growth of the fungus appears on the undersides of these spots. Spots enlarge and yellowing of the leaf, followed by brown discoloration. Finally, death of the entire leaf.	• Collect and destroy infected vine and plants from the field. • Avoid use of other cuccurbitacious crops in crop rotation. • Spray mancozeb or ridomil MZ- 72 @ 2.5 g liter of water on the crops.
Anthracrose **Pathogen:** *Colletotrichum lagenerium*	Leaf lesions begin as water soaked patches and then become yellowish circular spots. On water melon foliage the spots are irregular and turn dark brown or black. Stem cankers are less obvious on cucumbers.	Use healthy and certified Seed for sowing. • Collect and destroy infected vine and plants from the field. • Treat the seeds with thiram or carbendazim or carboxin @ 2.0-2.5 g/kg of seeds. • Spray mancozeb or ridomyl MZ-72 @ 2.5 g liter of water on the crops.
Cucumber mosaic **Pathogen:** *Cucumber mosaic virus*	Young leaves appear narrow. The leaves develop mosaic and blistering symptoms, which in later stage become wrinkled and misshaped. Growth of these plants is usually stunted and few are oddly Shaped and appear gray.	• Roguing of imfected plants from the field. • Spray insecticide like dimethoate or Confidor at 15 days intervals.

Okra

Disease and pathogen	Symptoms	Treatments
Wilt of okra **Pathogen:** *Fusarium oxysporum* f.sp. *vasinfectum*	Yellowing and stunting of the plants followed by wilting and rolling of the leaves and finally plants die. Dark streaks appear in the vascular bundles.	• Use healthy and certified seed tubers for sowing. • Follow crop rotation for 2-3 years. • Treat the seeds with carbendazim 2.5g/kg seeds.
Powdery mildew **Pathogen:** *Erysiphe cichoracearum*	White minute patches on the upper surface of lower leaves of the plant. Later these patches join together to form large white floury to grayish powdery coating on the leaves. The affected leaves turn yellow and finally drop.	• Spray topas (0.1%) or carbendazim (0.1%) or calixin (0.4-0.5 ml/L of water) on the crop at 15 days intervals.
Yellow vein mosaic **Pathogen:** Yellow vein mosaic virus	Vein clearing, vein chlorosis, yellow veins enclosing green patches of the leaf. Veins are thickened on lower surface of the leaf. Fruits are develop malformed and reduced in size, small, tough and fibrous	• Remove weeds from in and outside the field • Grow resistant varieties like Prabhani Kranti, G-7, Arka Anamika • Spray Confidor 200 SL (2ml/10L of water) on the crop till flowering.

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).

Bioformulation Pusa 5 SD

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 Bio-pellet 10G

Pusa 5 SD + Pusa Bio-pellet 10 G + Carboxin

Integrated disease management of Mungbean and Urdbean

A combination of seed treatment with thiamethoxam (Cruiser^{TM}) at 4 g/kg and carbendazim (Bavistin^{TM}) + tetramethyl thiuram disulphide (Thiram^{TM}) at 2.5 g/kg (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 minute thread like 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

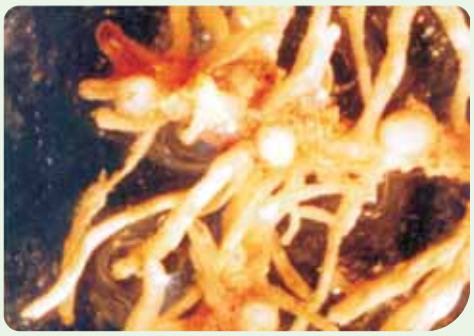
Same as for ear-cockle disease

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, aniseed 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, tubers 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%.

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 de-oiled neem-cake (0.5-1.0 t/ha) to soil 2-3 weeks before transplanting.

Root-knot nematode in tuberose: Same as in the case of Root knot nematode of vegetables.

Control

Avoid ratooning, as heavy losses occur in ratoon crops. Tuberose bulb treatment in 0.2-0.4% carbosulfan gives initial protection during crop growth against root-knot nematode infection.

Nematode infested brinjal roots with knots

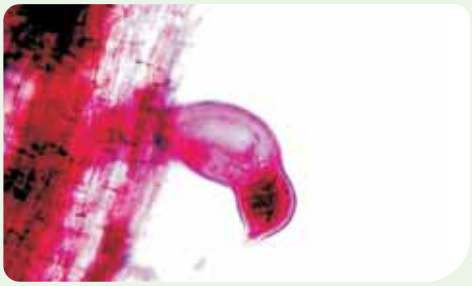
Leaf falls and yellowish leaves of nematode infested cucumber in polyhouse

Okra field infested with root knot

Root-knot nematode infected tuberose

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.

- 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.

Citrus nematode infested lemon tree

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.

Emergence of entomopathogenic nematode

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 can also take care of termite problem in the field. Nemagel formulation has been commercialized with the help of NRDC.

Sugarcane field infested with white grub
(inset) EPN-infected white grub

White grub management by entomopathogenic nematode *Heterorhabditis indica* infected Galleria cadavers: An entomopathogenic nematode *Heterorhabditis indica* infected *Galleria mellonella* cadavers has shown promising results in terms of a 25-66% reduction in white grub population and an increase in sugarcane yield to up to 6-8 tonnes/acre at different locations. The Division of Entomology, IARI has identified 12 overlapping species of grubs prevalent in the area. *H. indica* proved to be very promising as it migrates vertically (30 cm) and horizontally (45 cm) from the site of application within 90 days in the sandy loam soil of the infested area. *G. mellonella* cadavers infected with *H. indica* @ 5000 cadavers/acre are incorporated in the standing sugarcane crop during the first week of June, followed by another application a month later. The dead grubs take-up a characteristic red color and the nematode has shown good recycling ability as around 85,000 fresh nematodes emerge from the dead grubs to spread in the field.

8

Useful Agricultural Machines and Implements

Pusa Compost Sieving Machine

Pusa Basmati Paddy Thresher

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 for sale* at the Institute. The technical details and estimated cost of the useful equipments are given below:

Implements of Weeding for Field Preparation

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. This equipment is foldable which enables ease while transporting.

Technical details:

- Overall dimensions (l x w x h) : 1110 x 540 x 850 mm
- Wheel diameter : 44 cm
- Handle length : 90 cm
- Power source : One person
- Weight : 7 kg
- Estimated cost : ₹ 920/-

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 in standing posture, which results in less fatigue.
- Cost effective for weeding and inter-cultural operations.

Sowing Machines

Pusa Aqua Ferti-Seed Drill

Lack of proper soil moisture at root depth zone at the sowing time of *rabi* crops such as wheat, gram, mustard etc. makes sowing difficult, which affects the germination and growth of crops. This machine has been invented for dryland areas, which is more than 60% in the country. 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/seedling.

Technical details:

- Overall dimensions (l x w x h) : 2000 x 1650 x 1400 mm
- Field capacity : 0.4 ha /h
- Power source : 45 hp tractor
- Weight : 225 kg
- Estimated cost : ₹ 74,750/-

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 increased germination.
- Efficient utilization of water and fertilizer with seed and consumes about 10 m^3 (10,000 litres) of water/ ha.

Pusa Pre-germinated Paddy Seeder

The direct seeding of wet paddy on puddled soil has gained popularity in the recent time at National and International level. The direct paddy seeding gives faster and easier crop establishment, reduced labour use, lesser drudgery, earlier crop maturity, more efficient water use due to reduced crop duration and increased benefit-cost ratio. Pusa Pre-germinated Paddy Seeder is available in two forms - three and six rows.

Technical details:

Particulars		Three lined	Six lined
Overall dimensions (l x w x h)	:	1650 x 890 x 650 mm	1650 x 1250 x 650 mm
Person	:	1-2	2
Number of rows	:	3	6
Distance between rows	:	15-25 cm	15 cm
Capacity (ha/day)	:	0.2 ha/day	0.4 ha/day
Estimated cost	:	₹ 12,000/-	₹ 15,000/

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.

Seed may be dipped in salt solution (1-2 tea spoon salt/ litre of water) so that damaged seeds float on the surface of water. Floated seeds may be thrown out and remaining seeds may be washed with water and soaked in water for 24 hours. After removing the water, the soaked seeds is spread on gunny bags and 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.

Pusa Power Operated Seed Drill

Pusa Seed Drill is a walk behind equipment and useful for small and marginal farmers, particularly those of hilly areas, for sowing of different crops. This is 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:

- Overall dimensions (l x w x h) : 1350 x 920 x 500 mm
- 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 : Fluted roller type mechanism
- Diameter of wheel : 34 cm
- Estimated cost : ₹ 25,000/-

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.

Pusa 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-point control system is used for coupling with tractor.

Technical details:

- Overall dimensions (l x w x h) : 1800 x 1830 x 1130 mm
- Number of ridges : 3
- Number of furrow openers : 3
- Seeding mechanism : Plate type
- Number of cells on the plate : 8
- Estimated cost : ₹ 40,000/-

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.

Machine of Plant Protection

Pusa Solar Powered Knapsack Sprayer

Knapsack Sprayers are widely used by small and marginal farmers to spray plant protection chemicals by operating lever @ 16-20 stroke/minute which induces fatigue to workers along with greater variation in spray pressure causing inconsistency of application and in turn adversely affecting pest control and in long run it may lead to ground water pollution. In light of the above problem, solar powered spraying system has been developed which can be even fitted with the existing sprayer. The diaphragm type pump is able to create 4 kg/cm^2 pressure without pulsation, which is sufficient for fine & uniform spray.

Technical details:

The system consists of 12V DC motor with diaphragm type pump, non return two-way valve, safety control: high pressure switch, three head lance and acid-lead or Li-O battery.

- Swath width : 1.75 m
- Droplet size : 210-350 µm (at 40 psi)
- Field capacity : 0.35 ha/h
- Source of power : One person
- Nozzle spacing : Adjustable
- Power : Solar Chargeable Lead Acid Battery Pack (Charging time 2 h; Operation time 6 h or Directly by SPV 60 W)
- Estimated cost : ₹ 13,200/-

Advantages:

- Equipped with constant pressure system which gives quality spray i.e. uniformity, fine spray, effective & efficient control of pest is achievable.
- The acid-lead or Li-O battery can be charged by SPV panel of 60W.
- The fully charged battery is able to operate the sprayer for 6 hour continuously, which is adequate for a day operation.
- It enhances field capacity considerably and makes it suitable for row crop applications.
- A 100 mesh filter is provided just before nozzle, which enhances spray quality by filtering the spray material and prevents nozzle from clogging.
- Over and above, it is able to reduce farmer's drudgery as the lever operation has been replaced by solar powered

Machines of Harvesting and Threshing

Pusa Basmati Paddy Thresher*

An axial flow Pusa Basmati Paddy Thresher has been developed for threshing of basmati paddy without visible or invisible mechanical injuries with high labour efficiency, timeliness in completion of operation and also economizing the operation. The optimum rotation speed for cylinder is about 25 m/s. The high density polyethylene laminated tempered mild steel on spike tooth is found effective in reducing invisible injury to kernels.

Technical details:

- Power source : 45hp Tractor (PTO)
- Transport wheel : Pneumatic
- Feeding platform : Folding Type
- Output capacity : 1000-1500 kg/h
- Threshing efficiency : 99.0%
- Estimated cost : ₹ 2,00,000/-

Advantages:

- Significant reduction in cost for threshing (up to 83 %) than conventional method of threshing.
- It reduces labour requirement by 88% than conventional method with 4% point enhanced recovery.
- This machine can be towed to field hence, it further reduces labour and power requirement for transporting material to threshing site. It also reduces the losses which occur in handling of bulk material.
- Due to higher capacity, timely completion of the operation also enables farmers to complete other required farm operation for consecutive crop in time and harness its benefits.

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:

- Overall dimensions (l x w x h) : 1600 x 1300 x 1600 mm
- Capacity : 70 kg/h
- Power source : 2 hp electric motor
- Weight : 175 kg
- Seed damage (Max.) : 4%
- Estimated cost : ₹ 36,800 /-

Advantages:

- 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.

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.

Technical details:

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 : ₹ 15,000/-

Power Operated

- Overall dimension (l x w x h) : 1700 x 1200 x 1600 mm
- 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 : ₹ 50,000/-

Advantages:

- Suitable for efficient extraction of seeds of tomato, brinjal ash gourd 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.

Pusa Chaff Cutter Safety Interventions*

Every rural household irrespective of their socio-economic status having cattle keeps the chaff cutter, which is usually operated twice daily depending upon the number of cattle. Any member of family performs the operation and the chaff cuter is also accessible to children for playing. This is associated with many injuries in the rural households. The severities of injuries are also high as it has sharp blades and feed rollers. Inadvertently, body part coming in contact with the blades may results in amputation. Similarly hands getting trapped between the serrated power rollers also result in crushing injury. In order to prevent injuries the following interventions have been developed:

Technical details:

(a) **Blade Guard:** It consists of a metal guard made up of mild steel sheet and can be attached to the two existing blade bolts. It can be opened for sharpening of the blades.

(b) **Flywheel Lock:** It is spring loaded mechanical lock that prevents rotation of the flywheel in standby mode.

(c) **Warning Roller**: It consists of a serrated wooden roller that gives a warning when the hand is in danger zone while feeding the chaff cutter.

- Size of blade guard : 46 cm x 22 cm
- Length of roller : 17.6 cm
- Length of flywheel lock : 18 cm
- Total weight : 1.3 kg
- Estimated cost (Only safety kit) : ₹ 920/-
  (Chaff cutter with safety kit) : ₹ 9,775/-

Advantages:

- This prevents injuries during working and non-working conditions.
- It is easy to fabricate and install on existing and new chaff cutter.

Post Harvest Technology

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:

- Overall dimensions (l x w x h) : 1700 x 1100 x 950 mm
- Capacity : 150 kg/h
- Power source : 1 hp motor
- Estimated cost : ₹ 30,000/-

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:

- Overall dimension (l x w x h) : 5300 x 1950 x 2150 mm
- Capacity : 100-125 kg/h
- Power source : 6.5 hp diesel engine
- Weight : 1500 kg
- Trolley size : 3 m x 1.5 m
- Block size : 15 cm x 15 cm
- Estimated cost : ₹ 4,58,500/-

The weight of blocks ranges between 0.50 kg and 2.5 kg

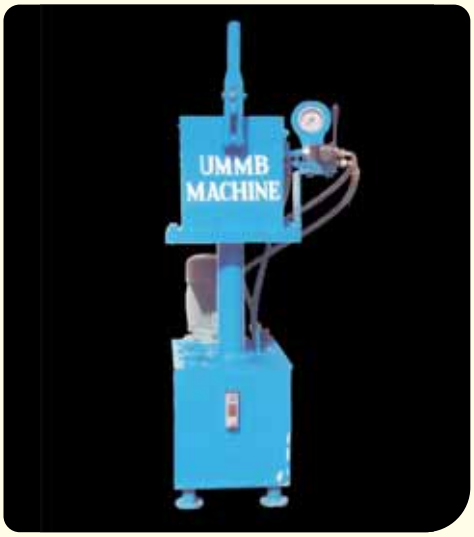
Advantages:

- 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 %



Technical details:

- Capacity : 150 kg/h
- Block size : 22.5 cm x 4.5 cm
- Weight : 200 kg
- Power source : 1 hp
- Estimated cost : ₹ 57,440/-

Advantages:

- The blocks fulfill the energy and protein requirement of animals.
- Feeding milch 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 valve, 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.

Main parts: Frame, hydraulic cylinder, electricity control panel

- Overall dimensions : 5200 x 2000 x 2100 mm
- Capacity : 200-250 kg/h
- Block size : 20 cm x 20 cm
- Power source : 25 hp electric motor three phase
- Weight : 400 kg
- Estimated cost : ₹ 8,26,900/-

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 increase its shelf life.
- It is very economical because transport to far-off places becomes easy.

Pusa 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:

- Overall dimensions (l x w x h) : 1400 x 800 x 1610 mm
- Capacity : 300-600 kg/h
- Power source : 1 hp electric motor
- Blower speed : 1440 rpm
- Size of grain hopper : 300 x 300 mm
- Weight : 40 kg
- Estimated cost : ₹ 27,600/-

Advantages:

- High quality cleaning enhances the quality of produce.
- Exhaust air blows off the dust and unwanted particles and the final product is collected clean.
- All types of grains can be cleaned by using this equipment.
- Two or more mixed grains can be separated by using this machine.
- Saves money and time.

Pusa Compost Turner cum Mixer*

The Pusa Compost Turner cum Mixer Machine is useful for thorough mixing of cow dung, farm residues and biomass for preparation of good quality compost.

Technical details:

- Overall dimensions (l x w x h) : 7200 x 5800 x 4000 mm
- Power source : 70 hp tractor
- Capacity : 3,000 tonnes per day
- Estimated cost : ₹ 6,32,500/-
- Estimated income : ₹ 10-15 lakh per annum

Advantages:

- Save one month time in compost making as compared to traditional method.
- Payback period is 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:

- Overall dimensions (l x w x h) : 5920 x 2020 x 2550 mm
- Power source : 55 hp tractor
- Capacity : 12 tonnes per h
- Estimated cost : ₹ 4,02,500/-

Advantages:

- The loader takes only 0.5 machine-h for loading a truck where as 15 man-h is required for manual operation
- Payback period is 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:

- Capacity (estimated) : 5 tonnes per h
- Power source : Three phase electric motors (2 hp, 3 hp and 3 hp)
- Estimated cost : ₹ 6,32,500/-

Advantages:

- Separation in different sizes for value addition (Smaller grades are used in pots).
- Payback period is 30 months.

Solar Energy Technology

Pusa Solar Powered Dryer

A blower is used to suck hot air from the flat plate collector to transfer it to the drying chamber of batch type forced convection dryer. To harness the solar power, a system has also been developed to run blower using solar energy. The DC power of the solar energy is converted into AC power through inverter. A battery is used to provide the backup in the absence of solar power.

Technical details:

- Overall dimensions (l x w x h) : 2740 x 1400 x 1050 mm
- Capacity of dryer : 300-400 kg
- No. of trays : 20
- Solar panel : 100 W x 4
- Blower : 375 W
- Inverter : 24V, 1250 VA
- Battery : 24V, 190 Ah
- Estimated cost (without solar) : ₹1,15,000/-
  (with solar) : ₹1,84,000/-

Advantages:

- It is suitable for drying of fruits and vegetables.
- By operating blower with solar energy, no conventional power is required thus saving cost of electrical power.
- It may be used in areas where there is no grid electricity.
- The above solar power pack may also be used for operation of refrigerator (90W), three tube lights (84W) and a Fan (50W) also.

Solar Lighting System

The lighting systems work from dusk to dawn. During the day, the solar energy is used for charging the battery. While in the evening and night when the solar energy is not available, the charge stored in the battery is used for the lighting system.

Technical details:

- Overall dimensions (l x w x h) : 3600 x 1200 x 1200 mm
- Solar Module : 40 Wp
- LED : 9 W
- Battery : 40 Ah
- Estimated cost : ₹ 22,500/

Advantages:

- The solar lighting system may be used for lighting for dusk to dawn particularly in rural areas where there is no power available.
- The light obtained from this system covers space of about 4 m.
- Reducing the height of lighting system may enable children to use it for reading also.

9

Advisory Services for Farmers

Farmers group visit to IARI

Agricultural Technology Information Centre, IARI

ATIC: Technology dissemination through single window delivery mechanism

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".

The Institute's Agricultural Technology Information Centre (ATIC) is a 'single window technology delivery mechanism' 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:

Farm advisory services

- Providing customized knowledge based on specific queries so that farmers can base their decisions on proper scientific information.
- Weather based-agro advisory services is made available to farmers.
- Besides personal visits, farmers can get benefit of farm advisory service through telephone help-line strengthened with interactive voice recording system.

Telephone Help-line

Pusa Agricom

- Telephone Based farm advisory through toll free *Kisan* helpline 'Pusa Agricom' (**1800-11-8989**) for farmers and other stakeholders from all over the country.

Pusa Helpline

- Telephone farm advisory through Pusa Helpline, 011-25841670.

Kisan Call Centre

- Second level of *Kisan* Call Centre (**1800-180-1551**) to provid help to those farmers of NCR areas whose queries can not be resolved by the level 1 experts.

Technology Products Sale

- 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

Exhibition: IARI technologies are exhibited to the farmers at ATIC using modern communication technologies like touch panel kiosk, illuminated display panels, screen rollers, models etc.

NCDEX Price Index Board: Display of the latest rates of agricultural commodities in various agricultural markets and anticipated rates for three months.

Farm Magazine: ATIC publishes Hindi bi-monthly farm magazine *'Prasar Doot'*. This incorporates timely articles by the experts from the institute and provides brief and appropriate information about different technologies developed by IARI.

Information through letters/e-mail: Farm information is also being communicated through letters/emails in response to farmers' queries. Remedial measures for their problems are also suggested through postal correspondence.

Crop cafeteria: Live demonstration in cropping system mode involving latest varieties of various *rabi* and *kharif* crops, vegetable crops, fruit trees and some important medicinal plants.

***Gobar* Gas Unit:** *Gobar* gas unit has been established at ATIC for information to the farmers, so that they can use this environmental friendly technology at large scale to save fuel and improve soil condition.

Bee Keeping Unit: Bee keeping unit (apiary) is being maintained as demonstration on agro-based enterprise to the visitors.

Sale of extension magazine, pamphlets, and other publications

S.No	Name of the publications for sale	Rate (₹)
1.	*Prasar Doot* (Bi-monthly Magazine) Subcription	₹ 15.00/- ₹ 90.00/-
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.	*Phal Vrikshon Ki Saghan Bagwani*	₹ 100.00/-
7.	*Krishi Machinikaran, Upyogi Yantra, Unka Rakhrakhaw, Evam Uplabdhta*	₹ 50.00/-
8.	*Government Support and Facilities for Farmers and Rural Development (English)*	₹ 10.00/-
9.	*Krishi aur Gramin Vikas Yojnayein Evam Suvidhayein (Hindi)*	₹ 30.00/-
10.	*Kharpatwar Niyantran Se Phasal Suraksha*	₹ 50.00/-
11.	*Parinagariya Kheti*	₹ 100.00/-
12.	Technological Option for Enhanced Productivity and Profit (English)	₹ 100.00/-
13.	*Uchcha Utpadan Evam Aay Hetu Unnat Krishi Proudyogikiyan (Hindi)*	₹ 100.00/-

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. Centre has operated transfer of technology programme of the Institute 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). Centre is currently working to fulfill its mandated work of technology assessment in four model villages in NCR and at nearly 50 locations spread over the country with State Agricultural Universities, ICAR Institutes and Voluntary Organisations (VOs) also showcasing and divulging the IARI technologies to the users for maximum outreach. The Institute has undertaken a partnership programme with selected NGO's for feasibility trials and promotion of agricultural technologies in their operational locations, a first of its kind in public-private partnership for agricultural transformation.

National Extension Programme

National Extension and IARI-VOs Collaborative Programmes

Technology assessment and promotion through demonstrations and feedback to research system: Demonstrations of improved varieties of different crops are carried out under direct supervision in Model Villages and in partnership with 15 SAUs /ICAR Institutes and 28 Voluntary Organisations. These demonstrations resulted into significant feedback about IARI varieties which is also provided to concerned breeders in respect to specific traits of the varieties.

Capacity Building of Farmers and Extension Professionals

CATAT regularly organises on campus training programmes for agricultural officials and progressive farmers of different states. In addition several field days and *kisan goshthies* are organised in operational areas. A toll free service (1800-11-8989) has been launched by IARI to facilitate communication with farmers and 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 goshthi)*.
- Display and sale of farm literature.
- Farmers' visit to experimental fields of IARI.
- Farm women empowerment workshop.
- Innovative farmers' meet.
- Awards to Progressive farmers.

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 polyhouse 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	38.00	35.00
		All Hybrids	–	125.00
		Parental Lines	143.00	**
2.	Paddy	PRH 10 (Hybrid)	–	200.00
		Hybrid		
		A Line	190.00	**
		B Line	39.00	**
		R Line	39.00	**
		Pusa Basmati 1121 (Pusa Sugandh 4) Pusa Basmati 6 (Pusa 1401)	65.00	60.00
		Pusa Punjab Basmati 1509	–	65.00
		Pusa Basmati 1 Improved Pusa Basmati 1		55.00
		Pusa Sugandh 2		50.00
		Pusa Sugandh 3		50.00
		Pusa Sugandh 5 (2511)		50.00
		Medium Varieties		
		Pusa 834, PNR 162, PNR 381 PNR 542, PNR 546 PNR 519, JD 6, Pusa 44	40.00	35.00
		Coarse Varieties		
		JD 6, JD 13, Pusa 677 etc.	38.00	35.00
3.	Wheat	All *Aestivum* varieties	42.00	32.00
		Durum varieties	46.00	38.00
		Dicoccum varieties		
		Desi varieties	46.00	40.00
			41.00	32.00
4.	Barley	Malt barley	46.00	35.00
5.	*Bajra*	Varieties & composites	80.00	65.00
		Hybrids	–	75.00
		Parental lines of Hybrid		
		A Line	190.00	**
		B Line	80.00	**
		R Line	80.00	**
6.	Pigeonpea *(Arhar)*	All varieties	110.00	100.00
		Parental lines of Hybrid		
		A Line	130.00	**
		B Line	90.00	**
		R Line	90.00	**

7.	Cowpea *(Lobia)*	All varieties	75.00	65.00
8.	Field peas	All varieties	55.00	50.00
9.	Gram	*Desi* type	80.00	75.00
		Kabuli type	110.00	90.00
10.	Lentil	All varieties	85.00	75.00
11.	*Moong*	All varieties	120.00	100.00
12.	*Lathyrus*	All varieties	–	40.00
13.	Cotton	Parental lines of Hybrid (Male & Female)	530.00	**
		Male Sterility System Based		
		A Line	600.00	**
		R & B Line	600.00	
		All varieties	150.00	**
14.	Delinted cotton	Parental lines all varieties	662.5	**
15.	Mustard	All varieties	70.00	65.00
16.	Soybean	All varieties	70.00	65.00
17.	Fodder Sorghum	PC 6/PC 9/PC 23, etc.	80.00	70.00
18.	*Berseem*		260.00	240.00
19.	Dhaincha		50.00	40.00
20.	Tobacco		-	45.00

* 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	375.00	300.00
2.	*Palak*	PJ/AG/Pusa Bharti	250.00	200.00
		Pusa Harit		200.00
3.	Spinach	Virginia Savoy	200.00+	150.00
4.	Amaranth	All varieties	500	400.00
5.	*Bathua*	Pusa Bathua No.1	–	150.00
6.	Lettuce	Great Lake	800.00+	600.00
		Chinese Yellow	600.00+	600.00
7.	Parsley	Moss Curled	–	200.00
8.	Celery	Ford Hook Emperor	–	200.00
9.	Okra	A 4/ Pusa Sawani/Pusa Makhmali/ Perkins Long Green	500.00	400.00
10.	Brinjal	All varieties	1750.00	1500.00
		All Hybrids		16000.00
		Parental lines of Hybrid (Female/Male)	25,000.00+	
11.	Chillies	Pusa Jwala/Pusa Sadabahar	1,500.00	1200.00
		Paprika/KTPL-19	7,500.00	2000.00

S. No.	Crops	Varieties	ICAR price for breeder seed (₹/kg)	Price of IARI seed * (₹/kg)
12.	Capsicum (Sweet pepper)	CW	7,500.00	5,000.00
		YW		3,000.00
		Pusa Deepti (KT-1)		20,000.00
		Parentals lines of Pusa Deepti (Female/Male)	25,000.00+	**
13.	Tomato	All Variety	2,250.00	2,000.00
		Pusa Divya Hybrid, Pusa Hybrids 1, 2, 4, 8		20,000.00
		Parental lines of Pusa Divya Hybrid Female/	35,000.00+	**
		Male	25,000.00+	
		Pusa Hybrids 1, 2, 4, 8 (Female/Male)	20,000.00+	
14.	Cowpea	Pusa Sukomal/	500.00	400.00
		Pusa Komal/other varieties	500.00	350.00
15.	Dolichous bean	PEP/Pusa Sem 2/Pusa Sem 3	380.00	250.00
16.	French bean	Contender	380.00	250.00
		Other varieties	380.00	200.00
17.	Winter bean	Pusa Sumeet/ Pusa Udit and others	150.00+	100.00
18.	Garden pea	All Varieties	250.00	100.00
19.	Cauliflower	Pusa Sharad/Pusa Meghna/Pusa Deepali/IJ/Pusa Himjyoti/and other new varieties	1,900.00	1,600.00
		Pusa Hybrid 2 & Pusa Kartik Sankar	–	6,000.00
		Snowball types (PSB 1/PSBK 1/KT 25, etc.)	4,375.00	3,500.00
		Parental lines of Hybrid (Female/Male)	12,000.00+	**
20.	Cabbage	Golden Acre/PM/PDH	1,500.00	1,200.00
		Hybrid 1 (KGMR 1)	–	8,000.0
		Parental lines, Female/	25,000.00 +	**
		Male	10,000.00 +	**
21.	Knol-Khol	White Viena/ Pusa Virat	1,500.00	1,000.00
22.	Brussels Sprout	Hild's Ideal	3,000.00 +	2,500.00
23.	Broccoli	KTS 1	3,000.00 +	2,500.00
24.	Radish	All varieties	625.00	450.00
25.	Turnip	All varieties	750.00	500.00
26.	Carrot	Pusa Kesar/Pusa Meghali/Pusa Yamdagni	1,000.00	700.00
		Pusa Rudhira & Pusa Vrishti	1,200.00	800.00
		Pusa Nayanjyoti (a Hybrid variety)		2,000.00
		Parental lines of Pusa Nayanjyoti Female	25,000.00 +	
		Male	5,000.00 +	
27.	Garden beet	DDR/Crimson Globe	600.00 +	500.00

S. No.	Crops	Varieties	ICAR price for breeder seed (₹/kg)	Price of IARI seed * (₹/kg)
28.	Onion	All varieties	1,250.00	1,000.00
29.	Bottle gourd	All varieties/PSPL/PN/PS	750.00	600.00
		Pusa Hybrid 3	–	2,000.00
		Parental lines of hybrid (Female/Male)	3,000.00 +	**
30.	Bitter gourd	PDM/Pusa Vishesh	1,000.00	700.00
		Pusa Hybrids 1 & 2		2,000.00
		Parental lines of hybrid (Female/Male)	5,000.00	**
31.	Sponge gourd	All varieties	750.00	600.00
32.	Ridge gourd	Pusa Nasdar/ Pusa Nutan	750.00	600.00
33.	Ash gourd	Pusa Ujwal	800.00	600.00
34.	Cucumber	All varieties	1,900.00	1,500.00
		Pusa Sanyog (Hybrid)		3,000.00
		Parental lines of hybrids Female	25,000.00 +	**
		Male	20,000.00 +	**
35.	Muskmelon	Pusa Madhuras/Pusa Sharbati	1,000.00	750.00
36.	Watermelon	SB/AY	1,900.00	1,200.00
37.	Pumpkin	Pusa Vikas/Pusa Vishwas	1,000.00	750.00
		Pusa Hybrid 1		2,000.00
		Parental lines of Pusa Hybrid 1 (Female/Male)	3,000.00 +	**
38.	Squash	Australian Green	1,000.00 +	700.00
		Pusa Alankar (Hybrid)	–	1,500.00
		Parental lines of Pusa Alankar (Female/Male)	3,000.00 +	**
39.	Snap melon	Pusa Shandar	–	300.00
40.	Vegetable mustard	Pusa Sag 1	–	300.00
41.	Asparagus bean	Red and Black	500.00	350.00
42.	Vegetables Seedlings (Plug Tray Production)	Solanaceous vegetables (OP)	–	₹ 1/Plant
		Solanaceous vegetables (Hybrid)	–	₹ 2/Plant
		Cucurbits	–	₹ 2/Plant
		Cole Crops	–	₹ 1/Plant
43.	Fruits sapling	Papaya in plastic pot (OP)	–	₹ 10/Plant
		Papaya in plastic pot (Hybrid)	–	₹ 20/Plant
		Banana (in plastic pot)	–	₹ 15/Plant

* 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**	–	₹ 25/5g
		Small seeded	–	₹ 20/1g
3.	Alstromeria	Rhizome	–	₹ 30/plant
4.	Bougainvillea	All types	–	₹ 20/plant
5.	Camellia (2 year old)		–	₹ 50/plant
	Camellia (4 year old)		–	₹ 100/plant
6.	Chrysanthemum/	Bare rooted	–	₹ 3/plant
	Dahlia cuttings	Rooted plant (plug tray)	–	₹ 5/plant
7.	Gladiolus	Corm	–	₹ 5/corm
8.	Marigold	African varieties PNG/PBG	₹ 6,000.00+	₹ 5,500/kg
		French variety Pusa Arpita		₹ 5,000/kg
9.	Nargis	Bulb	–	₹ 3/bulb
10.	Rose	Climber/Miniature	–	₹ 35/plant
		Cutting (un-rooted)	–	₹ 50/hundred
		Cutting (rooted)	–	₹ 100/hundred
		HT/Floribunda	–	₹ 50/plant
		HT/Floribunda (in pot)	–	₹ 70/plant
		Rose (bud)	–	₹ 2/bud
11.	Tuberose	Double	–	₹ 3/bulb
		Single	–	₹ 2/bulb
12.	Dahlia	Bulb	–	₹ 3/bulb
13.	Cyclamen	Non-flowered	–	₹ 30/plant
		Flowered	–	₹ 75/plant
14.	Primula	All varieties	–	₹ 30/plant

* 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	–	₹ 15/plant
2.	*Ber*	Bud (eye)	–	₹ 2/stick of 3-5 buds
		Budded plant in all 4 varieties	–	₹ 20/plant
3.	Citrus, Grape	Kagzi Kalan, Grape Fruit & Mousambi	–	₹ 30/plant
	& *Mousambi*	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	–	₹ 35/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	Pusa Peetamber/ Pusa Pratibha Pusa Lalima/ Pusa Shreshtha	–	₹ 125/plant
		Amrapalli/Mallika (hybrid)	–	₹ 75/plant
		Pusa Arunima (hybrid)/ Pusa Surya	–	₹ 90/plant
		Scion stick of hybrid	–	₹ 5/Scion
8.	Papaya	All varieties (saplings)		₹ 8/sapling
		All varieties (seed)	₹ 45,000/kg+	₹ 40,000/kg
9.	Peach	Florida Sun	–	₹ 25/plant
10.	Strawberry	All varieties	–	₹ 2/runner

* Prices inclusive of packaging charges
+ Prices fixed by IARI P.F.C.

Sources of IARI (Pusa) Seeds/ Technologies

Farmers can obtain the seeds of improved varieties/ plant saplings/ technologies developed by the Institute from following sources:

S. No.	Divisions/Centres/Units/Regional Stations	Technologies available for sale
1.	Agricultural Technology Information Centre (ATIC), IARI, New Delhi-110 012 Phone: Toll Free: 1800-11-8989 (Pusa Agri-com) 011-25841670 (Pusa Helpline), 011-25841039	IARI Seeds of *kharif* and *rabi* crops, vegetables, flowers and farm literatures.
2.	Division of Agricultural Engineering, IARI, New Delhi-110 012 Phone: 011-25842294 (O)	Agricultural implements and farm machinery.
3.	Division of Agricultural Chemicals, IARI, New Delhi-110 012 Phone: 011-25843272 (O)	Pusa Hydrogel: Carborundum Universal Limited, 11/5 B Param Tower, IInd Floor Pusa Road, New Delhi -110005. Mob. : +919873046176.
4.	Division of Floriculture and landscaping, IARI, New Delhi- 110 012 Phone: 011-25841929 (O)	Seeds/planting materials of flower plants
5.	Fruit and Horticultural Technology Division, IARI, New Delhi- 110 012 Phone: 011-25843214 (O)	Fruit plant saplings suitable for northern plains.
6.	Seed Production Unit, IARI New Delhi-110 012. Phone: 011-25842686 (O)	IARI seeds of field crops, vegetables, flowers, and saplings of fruit plants.
7.	IARI Regional Station, Karnal (Haryana) -132 001. Phone: 0184-2267169 (O)	IARI Seeds of *kharif* and *rabi* crops, vegetables, flowers and saplings of fruit plants.

8.	IARI Regional Station, Indore (Madhya Pradesh) - 452 001. Phone: 0731-2702921 (O)	Seeds of wheat varieties suitable for Central zone and Papaya c.v. Pusa Nanha.
9.	IARI Regional Station, Pusa, Samastipur (Bihar)-848 125. Phone: 06274-240232 (O)	Seeds of wheat and paddy varieties suitable for NEPZ and seeds of Papaya c.v. Pusa Dwarf.
10.	IARI Regional Station, Katrain, Kullu valley, (Himachal Pradesh) -175 129. Phone: 01902-241280 (O)	IARI seeds of winter and summer vegetable crops.
11.	IARI Regional Station, Amartara, Shimla-171 004 (Himachal Pradesh) Phone: 0177-2808766 (O)	Saplings of fruits plants and seeds of wheat varieties suitable for northern hilly regions.
12.	IARI Regional Station, Kalimpong -734 301 (West Bengal) Phone: 03552-255446 (O)	Virus free saplings of Mandarin and large Cardamom.
13.	IARI Regional Station, Pune (Maharashtra)- 411 005. Phone: 020-25537601(O)	Saplings of Papaya.
14.	IARI Regional Station, Wellington, (Tamil Nadu)-643 231. Phone: 0423-2234796 (O)	Seeds of wheat varieties suitable for southern hilly regions.
15.	IARI Regional Station, Dharwad (Karnataka)-580 005. Phone: 0836-2442983 (O)	IARI seeds of pulses.

Address of IARI

Indian Agricultural Research Institute (IARI)
New Delhi 110 012, India
Phone: 011-25733367, 25843375
Fax: +91-11-25846420
Toll Free Farmers Helpline: 1800-11-8989
Website: www.iari.res.in

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

Nano-pesticides and nano-formulations of pesticides for high efficacy

1. Nano-pesticides

Nano-sulphur and Nano-hexaconazole were prepared. Products exhibited 2-6 times higher fungicidal activity.

2. Prepared nano-formulations

- Carbofuran against nematode in tomato
- Cyfluthrin against stored pests
- Azadirachtin against stored pests
- Imidacloprid against stem fly and white fly in soybean
- Thiamethoxam against stem fly and white fly in soybean
- Thiram for soybean seed quality enhancement

Products were more (20-40%) effective than commercial formulations

Important agro-chemicals

Insecticide	Fungicide	Bactericide	Acaricide	Rodenticide	Herbicide
Acephate	Ametroctradin	Agrimycin	Bifenazate	Bromadiolone	Ethoxysulfuron
Acetamiprid	Aureofungin	Kasu-B	Carbofuran*	Coumachlor	2,4-Dichlorophenoxy Acetic Acid
Alphacypermethrin	Azoxystrobin	(Kasugamycin 3% SL)	Cypermethrin*	Coumatetralyl	Carfentazone Ethyl
Azadirachtin (Neem Products)	Benomyl	Streptomycin	Dicofol	Zinc Phosphide	Alachlor
Bendiocarb	Bitertanol	Sheathmar	Dichlorovos*		Anilophos
Benfuracarb	Captan	(Validamycin 3% L)	Dimethoate*		Atrazine
Bifenthrin**	Carbendazim	Tetracycline	Fenvalerate*		Azimsulfuron
Buprofezin	Carboxin		Kelthane		Bensulfuron Methyl
Carbaryl**	Carpropamid		Phosalone*		Bispyribac Sodium
Cartap hydrochloride	Chlorothalonil		Propuxor*		Butachlor
Chlorantraniliprole	Copper Hydroxide		Propergite		Chlorimuron ethyl
Chlorfenapyr**	Copper Oxychloride		Triazophos*		Chlorpropham
Chlorfluazuron	Cyazofamid				Cinmethylene
Chlorpyriphos**	Cymoxanil				Clodinafop-propargyl
Chlothianidin	Difenoconazole				Clomazone
Chromafenozide	Dimethomorph				Cyhalofop-butyl
Cyfluthrin	Dithianon				Diclofop-Methyl
Cyphenothrin	Dodine				Diuron
Diclorvos (DDVP)	Edifenphos				Glyphosate
Dimethoate	Famoxadone				Fluchloralin
Dinotefuron	Fenamidone				sulphosulphuron
Emamectin Benzoate	Fenarimol				
Ethion	Karathane**				
Ethofenprox	Mancozeb				
Fenobucarb (BPMC)	Propiconazole				
Fenazaquin	Sulphur dust**				
Fenpropathrin**	Thiram				
Fipronil**					
Flubendiamide					
Imidacloprid					
Indoxacarb					
Lambdacyhalothrin					
Monocrotophos					
Malathion**					
Phorate**					
Quinalphos**					

** Also work as Acaricide, * Also work as Insecticide

Agro-chemicals banned or restricted in use in India

(As on 31th Dec, 2012)

A. Pesticides Banned

1. Aldicarb
2. Aldrin
3. Benzene Hexachloride (BHC)
4. Calcium Cyanide
5. Chlorbenzilate
6. Chlordane
7. Chlorofenvinphos
8. Copper Acetoarsenite
9. Dibromochloropropane
10. Dieldrin
11. Endosulfan*
12. Endrin
13. Ethyl Mercury Chloride
14. Ethyl Parathion
15. Ethylene Dibromide
16. Heptachlor
17. Lindane (Gamma-HCH)
18. Maleic Hydrazide
19. Menazon
20. Metoxuron
21. Nitrofen
22. Paraquat Dimethyl Sulphate
23. Pentachloro Nitrobenzene
24. Pentachlorophenol
25. Phenyl Mercury Acetate
26. Sodium Methane Arsonate
27. TCA (Trichloro acetic acid)
28. Tetradifon
29. Toxaphene (Camphechlor)
30. Carbofuron 50% SP
31. Methomyl 12.5% L
32. Methomyl 24% formulation
33. Phosphamidon 85% SL
34. Captafol 80% Powder
35. Nicotin Sulfate

Note: Endosulfan* has been banned by the Supreme Court of India w.e.f. 13-05-2011 for production, use & sale, all over India, till further orders vide ad-Interim order in the Writ Petition (Civil) No. 213 of 2011.

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 PPM = 1 Milligram per Kilogram
1 Percentage = 100^{th} part of quantity

Agro-chemicals restricted in use in India

(As on 31th Dec, 2012)

S. No.	Insecticide	Details of Restrictions
1.	Aluminium Phosphide	The pest control operations may be undertaken only by Govt./Govt. undertakings / Govt. organizations / pest control operators under the strict supervision of Govt. experts. The production, marketing and use of Aluminium Phosphide tube packs with a capacity of 10 and 20 tablets of 3 g each of Aluminium Phosphide are banned completely.
2.	Captafol	The use as foliar spray is banned. Captafol shall be used only as seed dresser. The manufacture of Captafol 80 % powder for dry seed treatment (DS) is banned for use in the country except manufacture for export.
3.	Cypermethrin	Cypermethrin 3 % smoke generator, is to be used only through pest control operators and not allowed to be used by the general public.
4.	Dazomet	The use is not permitted on Tea.
5.	Diazinon	Banned in agriculture except for household use.
6.	Dichloro Diphenyl Trichloroethane (DDT)	The use of DDT for the domestic public health programme is restricted up to 10,000 metric tonnes per annum, except in case of any major outbreak of epidemic. Use in agriculture is withdrawn.
7.	Fenitrothion	The use of fenitrothion is banned in agriculture except for locust control in scheduled desert area and public health.
8.	Fenthion	Banned in agriculture except for locust control, household and public health.
9.	Lindane (Gamma-HCH)	Banned for manufacture, import or formulate.
10.	Methoxy Ethyl Mercuric Chloride (MEMC)	Banned completely except for seed treatment of potato and sugarcane.
11.	Methyl Bromide	Methyl bromide may be used only by Govt./Govt. undertakings/Govt. organizations / pest control operators under the strict supervision of Govt. experts.
12.	Methyl Parathion	Methyl parathion 50 % EC and 2% DP formulations are banned for use on fruits and vegetables. The use is permitted only on those crops approved by the registration committee where honeybees are not acting as a pollinators.
13.	Monocrotophos	Banned for use on vegetables.
14.	Sodium Cyanide	Restricted for fumigation of cotton bales under expert supervision approved by the plant protection advisor to Govt. of India.