Third Edition

Biofortified Varieties: Sustainable Way to Alleviate Malnutrition

Indian Council of Agricultural Research
New Delhi 110 001

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भाकृअनुप
ICAR

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. . . भारत में पौषण अभियान को ताकत देने वाला एक और अहम कदम आज उठाया गया है। आज गेहूँ और धान सहित अनेक फसलों के 17 नए बीजों की वैराइटी देश के किसानों को उपलब्ध कराई जा रही हैं। हमारे यहाँ अक्सर हम देखते हैं कि कुछ फसलों की सामान्य वैराइटी में किसी न किसी पौष्टिक पदार्थ या micronutrient की कमी रहती है। इन फसलों की अच्छी वैराइटी - Biofortified variety इन कमियों को दूर कर देती है, अनाज की पौष्टिकता बढ़ाती है। . . . ऐसे बीजों की research और development में भी बहुत प्रशंसनीय काम हुआ है . . . ।

– Prime Minister of India on the occasion of World Food Day
on 16th October, 2020




POSHAN Abhiyaan

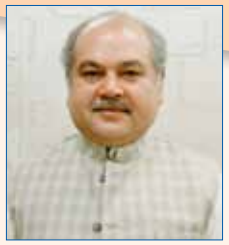
PM's Overarching Scheme for Holistic Nourishment

सही पोषण - देश रोशन

नरेन्द्र सिंह तोमर
NARENDRA SINGH TOMAR

सत्यमेव जयते

कृषि एवं किसान कल्याण,
ग्रामीण विकास तथा पंचायती राज मंत्री
भारत सरकार
कृषि भवन, नई दिल्ली
MINISTER OF AGRICULTURE & FARMERS' WELFARE,
RURAL DEVELOPMENT AND PANCHAYATI RAJ
GOVERNMENT OF INDIA
KRISHI BHAWAN, NEW DELHI



MESSAGE

India has achieved food grain production of 284.95 million tonnes during 2018-19, an enhancement of 5.6-folds with respect to 50.8 million tonnes in 1950-51. This bumper food grain production is primarily attributed to cultivation of high yielding crop varieties and hybrids developed by the National Agricultural Research System (NARS) led by Indian Council of Agricultural Research (ICAR). However, during the process of developing high yielding varieties, enough attention was not given towards nutrition. Though these improved cultivars produce high grain yield, the concentration of some of the most important nutrients are far below the required level. Malnutrition caused due to consumption of food with unbalanced nutrition has emerged as a major health problem. Crop biofortification is the most sustainable and cost-effective approach to address malnutrition.

It's a great pleasure to learn that ICAR and State Agricultural Universities (SAUs) have made significant progress in development of high yielding biofortified varieties and hybrids in cereals, millets, pulses, oilseeds, vegetables and fruits. Dedication of 17 biofortified crop varieties to the nation by Hon'ble Prime Minister on the occasion of 'World Food Day-2020' is an endorsement of country's preparedness to alleviate malnutrition through sustainable approach. The information on biofortified cultivars was earlier published in the form of a booklet entitled '***Biofortified Varieties: Sustainable Way to Alleviate Malnutrition***'. Now this publication has been updated as 'third edition' with 71 biofortified varieties of 16 different crops. I congratulate the developers of these varieties and hybrids, and appreciate the ICAR for this great initiative.

(NARENDRA SINGH TOMAR)

Dated: 12 November, 2020
New Delhi

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परशोत्तम रुपाला
PARSHOTTAM RUPALA

सत्यमेव जयते

राज्य मंत्री
कृषि एवं किसान कल्याण
भारत सरकार
Minister of State For
Agriculture & Farmers Welfare
Government of India

MESSAGE

Nutritious food is central to nation's growth, development and prosperity. However, malnutrition has emerged as a major health challenge in 21st century, and is being aptly addressed through Sustainable Development Goals (SDGs) chartered by United Nations. Various strategies viz., 'food-fortification', 'medical-supplementation' and 'dietary-diversity' are used to alleviate malnutrition. However, these strategies sometimes are limited by lack of purchasing power, robust distribution systems and crop seasonality. On the other hand, 'biofortification' of crop is regarded as the preferred choice as it is sustainable and cost-effective, and nutrients reach the target people in natural form.

I am extremely happy to know that Indian Council of Agricultural Research (ICAR) under the National Agricultural Research System (NARS), has developed 71 cultivars of cereals, millets, pulses, oilseeds, vegetables and fruits through plant breeding. These varieties and hybrids rich in one or more nutrients and at par with the traditional ones for grain yield, have been released for commercial cultivation in India. My heartiest congratulations to all the developers of these biofortified cultivars.

The bulletin entitled '***Biofortified Varieties: Sustainable Way to Alleviate Malnutrition***' would help in their popularization. I am sure that this great effort by ICAR would be a key component for achieving 'malnutrition free India' and provide prosperous and healthy future to my fellow countrymen.

(PARSHOTTAM RUPALA)

Dated: 12 November, 2020
New Delhi

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कैलाश चौधरी
KAILASH CHOUDHARY

कृषि एवं किसान कल्याण
राज्य मंत्री
भारत सरकार
MINISTER OF STATE FOR AGRICULTURE & FARMERS WELFARE
GOVERNMENT OF INDIA

MESSAGE

Healthy society is a key component of a successful nation. Though we have achieved record food grains in recent past, widespread malnutrition in the country remains as the worrying factor. Malnutrition not only affects growth and development in humans, but also causes severe economic loss. Nutritious grains rich in essential nutrients play pivotal role in providing balanced food through sustainable approach.

I am pleased to hear that Indian Council of Agricultural Research (ICAR) led National Agricultural Research System (NARS) has developed and released 71 nutrition-rich crop cultivars in important crops like rice, wheat, maize, pearl millet, finger millet, small millet, lentil, groundnut, linseed, mustard, soybean, cauliflower, potato, sweet potato, greater yam and pomegranate. These cultivars have been improved for essential nutrients viz., iron, zinc, calcium, protein, lysine, tryptophan, provitamin-A, anthocyanin, vitamin-C, oleic acid and linoleic acid. The concentration of several anti-nutritional factors viz., erucic acid, glucosinolate and trypsin inhibitor has been significantly reduced in some of the cultivars. Off-flavour of soybean grains has also been reduced. These biofortified cultivars with balanced concentration of nutrients are also high yielding, thus ideal for meeting country's 'food and nutritional security'.

I am sure that bulletin entitled ***'Biofortified Varieties: Sustainable Way to Alleviate Malnutrition'*** would serve as the catalyst to achieve 'food and nutritional security' in the country, and remove malnutrition in all forms by 2030 as envisaged in the Sustainable Development Goals (SDGs).

(KAILASH CHOUDHARY)

Dated: 12 November, 2020
New Delhi

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

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
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FOREWORD

Malnutrition leads to poor health and increased susceptibility to various diseases thereby reduces work efficiency in humans. It poses serious socio-economic implications as well. Considering its widespread ramification, global community in 2015 set 'Sustainable Development Goals' (SDGs) to achieve a better and more sustainable future for all. SDGs aim to remove malnutrition in all forms by 2030. Of the 17 SDGs, SDG2 (Zero Hunger) vows to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture. SDG3 (Good Health and Well-being) aims to ensure healthy lives and promote well-being of people at all ages. It has been estimated that alleviating malnutrition is one of the most cost-effective steps with every $1 invested in proven nutrition programme offers benefits worth $16.

Dedication of 17 biofortified crop varieties by the Hon'ble Prime Minister to the nation on the occasion of 'World Food Day-2020' is a testimony of commitment of Indian Council of Agricultural Research (ICAR) towards fulfilling country's food and nutritional security. So far, ICAR has developed 71 biofortified cultivars of 16 crops that can be integrated into the food chain to enable better health to human and animal populations. This bulletin entitled, ***"Biofortified Varieties: Sustainable Way to Alleviate Malnutrition"*** highlights the yield potential along with respective nutritional characteristics foresighting nutritional security in the country. I dedicate this information bulletin to all our fellow citizens.

(T. MOHAPATRA)

Dated: 12 November, 2020
New Delhi

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Introduction

Nutritious diet is vital for proper growth and development in humans. It helps preventing diseases, besides maintaining the body metabolism for physical- and mental- well being. Food provides energy, protein, essential fats, vitamins, antioxidants and minerals to meet our daily metabolic requirement[1]. Most of them cannot be synthesized in human body, therefore are to be supplemented through diet. Further, anti-nutritional factors present in edible parts of the food exert adverse affects on human health.

Indian Council of Agricultural Research (ICAR) has improved the nutritional quality in high yielding varieties of cereals, pulses, oilseeds, vegetables and fruits using breeding methods[2,3]. Special efforts were initiated during 12th Plan with the launching of a special project on Consortium Research Platform on Biofortification. Concerted efforts in collaboration with other national and international initiatives has led to the development of 71 varieties of rice (7), wheat (22), maize (11), pearl millet (8), finger millet (3), small millet (1), lentil (2), groundnut (2), linseed (1), mustard (3), soybean (3), cauliflower (1), potato (2), sweet potato (2), greater yam (2) and pomegranate (1). In addition, a large number of advance elite materials are in pipelines and will be released in due course of time. These biofortified varieties assume great significance to achieve nutritional security of the country.

Special efforts are being made to popularize these biofortified varieties among masses. Quality seeds of biofortified varieties are being produced and made available for commercial cultivation. Extension Division of ICAR has also launched two special programmes viz. Nutri-sensitive Agricultural Resources and Innovations (NARI) and Value Addition and Technology Incubation Centres in Agriculture (VATICA) for up-scaling the biofortified varieties through its Krishi Vigyan Kendras (KVKs)[1].

Types of malnutrition

Malnutrition is caused by consumption of unbalanced diet[1]. It affects most of the world's population at some point in their lifecycle during infancy to old age. Every country experiences one or the other form of malnutrition. It affects all geographies, age groups and people from rich to poor. Malnutrition exists in different forms[4]:

- ***Undernutrition:*** Lack of proper nutrition caused by not having enough food.
- ***Stunting:*** Low height as per age in children under five years of age due to limited access to food, health and care.
- ***Wasting:*** Thin for their height in children under five years of age because of acute food shortages or disease.
- ***Micronutrient deficiencies:*** Suboptimal nutritional status caused by lack of intake, absorption or use of one or more vitamins or minerals.
- ***Moderate and severe thinness or underweight:*** A body mass index (BMI) <18.5 indicates underweight in adult populations, while a BMI <17.0 indicates moderate and severe thinness.
- ***Overweight and obesity:*** Excessive weight as per height is classified as overweight and obesity in adults. BMI ≥25 is considered overweight, while ≥30 is treated as obesity.

Status of malnutrition

Malnutrition contributes to increased morbidity, disability, stunted mental and physical growth, and reduced national socio-economic development. The extent of malnutrition worldwide as well as in India is presented below:

Global scenario:

- Two billion people suffer from micronutrient deficiency or 'hidden hunger'[4]
- 820 million people are undernourished[5]
- 149 million (21.9%) children (<5 years) are stunted[6]
- 49.5 million (7.3%) children (<5 years) possess wasting[6]
- Nearly 45% of deaths among children (<5 years) are linked to malnutrition[4]
- 88% of the countries experience at least two types of malnutrition[4]
- 29% of the countries possess three types of malnutrition[4]
- South Asian region is affected the most by malnutrition with 31.7% and 14.3% of the children (<5 years) being stunted and wasted, respectively[6]
- Malnutrition contributes to loss of 11% GDP in Asia and Africa[7]
- Malnutrition in all its forms could cost society up to US$3.5 trillion per year[4]

Status of malnutrition

Indian scenario:

- 21.9% of population lives in extreme poverty[8]
- 15.2% of people are undernourished[8]
- 38.4% of the children (<5 years) are stunted, 21.0% are wasted and 35.7% of the children are under-weight[9]
- Stunting varies greatly (12.4-65.1%) across districts, with 239 of 640 districts having stunting levels above 40%[10]
- 58.4% of the children (6-59 months), 53% of the adult women and 22.7% of adult men are affected due to anaemia[9]
- 70% of children (<5 years) are estimated to be iron deficient[11]
- 38% of children (<5 years) are estimated to be deficient in zinc[11]
- India loses over US$12 billion in GDP per year to vitamin and mineral deficiencies[11]

Nutrients & their functions

Nutritional factors:

Protein: It provides essential amino acids for growth and tissue repair. Its deficiency leads to poor intellectual development, disorderly physical functioning and even mortality. Diet deficient in protein leads to kwashiorkor and marasmus disorders among humans.

Lysine: It is a building block in protein synthesis besides serving as precursor for several neurotransmitters and metabolic regulators. Deficiency of lysine leads to fatigue, dizziness, nausea, anaemia, delayed growth, loss of appetite and degeneration of reproductive tissue.

Tryptophan: It is also a building block of proteins, and functions as precursors for several neurotransmitters and regulators of metabolic pathways. Its deficiency leads to depression, anxiety and impatience. Weight loss and slow growth in children are the major symptoms of tryptophan deficiency.

Iron: It is a mineral element required for the proper functioning of muscle and brain tissues. It carries oxygen from the lungs to various tissues by red blood cell haemoglobin. The occurrence of anaemia is the most common characteristics of iron deficiency in human. Deficiency of iron also causes retarded growth and development.

Zinc: It is a mineral element which serves as cofactor in as many as 300 enzymes required in humans. It is required for the regulation of synthesis and degradation of nucleic acids, proteins, lipids and carbohydrates. Zinc deficiency leads to retardation in growth, loss of appetite, impaired immune function and increased susceptibility to infections.

Calcium: It is a mineral element required to build and maintain strong bones and teeth. It also plays a role in muscle movement and cardiovascular function. Deficiency of calcium leads to osteoporosis which causes the bones to become brittle. Dental problems, cataracts and alterations in the brain are the other associated symptoms.

Vitamin-A: It is also called as 'retinol' and is essentially required for the normal functioning of the visual system, growth and development, maintenance of epithelial cell integrity, immune system and reproduction. Night blindness is the hallmark of vitamin-A deficiency. Xerophthalmia and keratomalacia caused due to structural alterations of the conjunctiva and cornea may also follow. Further chances of anaemia, diarrhoea, measles, malaria and respiratory infections are also enhanced.

Vitamin-C: It is required for metabolism and repair of various tissues such as skin, bone, teeth and cartilage. Vitamin-C helps in iron absorption from the gastrointestinal tract. Deficiency leads to scurvy which is characterized by bleeding gums, bruising and poor wound healing in the teeth and is also associated with joint and muscle pains.

Anthocyanins: These are pigments that give red, purple, and blue colours in plant parts. Anthocyanins act as antioxidants and help removing harmful free radicals produced inside the body. Anthocyanins possess antidiabetic, anticancer, anti-inflammatory, anti-microbial, and anti-obesity effects, as well as prevention of cardiovascular diseases.

Oleic acid: It is a mono unsaturated fatty acid present in oil. Monounsaturated fat in the diet is associated with decreased low-density lipoprotein (LDL) cholesterol and reduced risk of coronary heart disease.

Linoleic acid: It is a polyunsaturated fatty acid present in oil. It reduces total and LDL cholesterol, therefore good for cardiovascular functions.

Anti-nutritional factors:

Erucic acid: It is a monounsaturated fatty acid found in rapeseed and mustard oil. High concentration of erucic acid in edible oils impairs myocardial conductance, causes lipidosis in children and increases blood cholesterol.

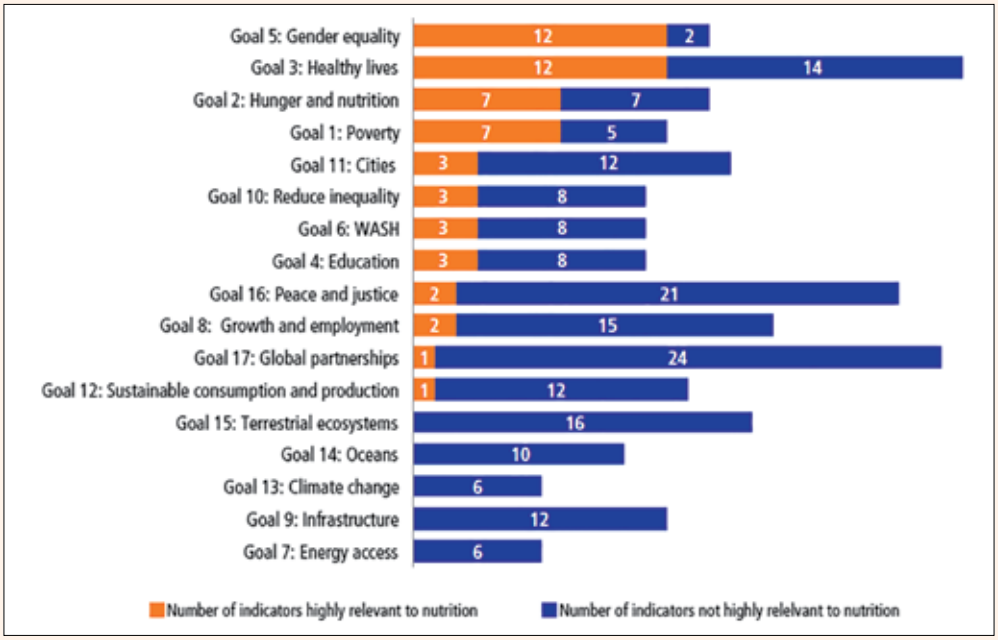
Glucosinolates: It is a group of thioglucosides mainly found in Brassicaceae family. Glucosinolates produce glucose, sulphate and other products when broken down by myrosinase. Higher consumption is detrimental to animal health as these reduce the feed palatability and affect the iodine uptake by the thyroid glands, which in turn lowers feed efficiency and weight gains particularly in non-ruminants such as pigs and poultry.

Kunitz trypsin inhibitor (KTI): It is a non-glycosylated protein that possesses adverse effects on growth of humans primarily through inhibition of trypsin in the digestive tract leading to indigestion. KTI constituting the major portion of total trypsin inhibitors in soybean, is considered detrimental to human health.

Lipoxygenase: It is an enzyme that plays role in the development of unpleasant flavour in foods made from soybean by oxidation of polyunsaturated fatty acids. The beany off-flavour reduces consumers' preference towards soybean as food.

Sustainable Development Goals (SDGs)

United Nations (UN) in 2015 set 17 Sustainable Development Goals (SDGs) to chart a path for meeting current human needs without compromising the ability of future generations to meet their needs[8]. At the core, SDGs aim to eliminate extreme poverty, hunger, and malnutrition; conserve environment and ensure that all people enjoy peace and prosperity by 2030. Twelve of the 17 goal-indicators are related to nutrition.



Source : 2016 Global Food Policy Report[8]

ICAR is committed to SDGs through development of high yielding biofortified crop varieties.

Rice: CR Dhan 310

(Pure line variety)

Protein 10.3 %

- Rich in protein (10.3 %) in polished grains in comparison to 7.0-8.0 % in popular varieties
- Grain yield: 45.0 q/ha
- Maturity: 125 days
- Suitable for irrigated mid-early conditions in *kharif*
- Adaptation: Odisha, Madhya Pradesh and Uttar Pradesh
- Developed by ICAR-National Rice Research Institute, Cuttack

Year of release: 2016

Rice: DRR Dhan 45

(Pure line variety)

Zinc 22.6 ppm

- Rich in zinc (22.6 ppm) in polished grains in comparison to 12.0-16.0 ppm in popular varieties
- Grain yield: 50.0 q/ha
- Maturity: 130 days
- Suitable for irrigated conditions in *kharif*
- Adaptation: Karnataka, Tamil Nadu, Andhra Pradesh and Telangana
- Developed by ICAR-Indian Institute of Rice Research, Hyderabad

Year of release: 2016

Rice: DRR Dhan 48

(Pure line variety)

Zinc 24.0 ppm

- Rich in zinc (24.0 ppm) in polished grains in comparison to 12.0-16.0 ppm in popular varieties
- Grain yield: 52.0 q/ha
- Maturity: 138 days
- Suitable for irrigated conditions in *kharif*
- Adaptation: Andhra Pradesh, Telangana, Tamil Nadu, Karnataka and Kerala
- Developed by ICAR-Indian Institute of Rice Research, Hyderabad

Year of release: 2018

Rice: DRR Dhan 49

(Pure line variety)

Zinc 25.2 ppm

- Rich in zinc (25.2 ppm) in polished grains in comparison to 12.0-16.0 ppm in popular varieties
- Grain yield: 50.0 q/ha
- Maturity: 130 days
- Suitable for irrigated conditions in *kharif* and *rabi*
- Adaptation: Gujarat, Maharashtra and Kerala
- Developed by ICAR-Indian Institute of Rice Research, Hyderabad

Year of release: 2018

Rice: Zinco Rice MS

(Pure line variety)

Zinc 27.4 ppm

- Rich in zinc (27.4 ppm) in polished grains in comparison to 12.0-16.0 ppm in popular varieties
- Grain yield: 58.0 q/ha
- Maturity: 135 days
- Suitable for early and medium sowings under rainfed and irrigated conditions in *kharif*
- Adaptation: Chhattisgarh, West Bengal and Odisha
- Developed by Indira Gandhi Krishi Vishwavidyalaya, Raipur under ICAR-All India Coordinated Research Project on Rice

Year of release: 2018

Rice: CR Dhan 311 (Mukul)

(Pure line variety)

Protein 10.1 %

Zinc 20.1 ppm

- Rich in protein (10.1 %) and zinc (20.1 ppm) in polished grains in comparison to 7.0-8.0 % protein and 12.0-16.0 ppm zinc in popular varieties
- Grain yield: 46.2 q/ha
- Maturity: 124 days
- Suitable for rainfed shallow lowland and medium land in *kharif*
- Adaptation: Odisha
- Developed by ICAR-National Rice Research Institute, Cuttack

Year of release: 2018

Rice: CR Dhan 315

(Pure line variety)

Zinc 24.9 ppm

- Rich in zinc (24.9 ppm) in polished grains in comparison to 12.0-16.0 ppm zinc in popular varieties
- Grain yield: 50.0 q/ha
- Maturity: 130 days
- Suitable for irrigated conditions in *kharif*
- Adaptation: Maharashtra and Gujarat
- Developed by ICAR-National Rice Research Institute, Cuttack

Year of release: 2020

Wheat: WB 02

(Pure line variety)

Iron 40.0 ppm

Zinc 42.0 ppm

- Rich in iron (40.0 ppm) and zinc (42.0 ppm) in comparison to 28.0-32.0 ppm iron and 30.0-32.0 ppm zinc in popular varieties
- Grain yield: 51.6 q/ha
- Maturity: 142 days
- Suitable for irrigated timely sown conditions in *rabi*
- Adaptation: Punjab, Haryana, Delhi, Rajasthan (excluding Kota & Udaipur division), Western Uttar Pradesh (except Jhansi division), Jammu and Kathua district of Jammu & Kashmir, Paonta Valley and Una district of Himachal Pradesh and Tarai region of Uttarakhand
- Developed by ICAR-Indian Institute of Wheat & Barley Research, Karnal

Year of release: 2017

Wheat: HPBW 01

(Pure line variety)

Iron
40.0 ppm

Zinc
40.6 ppm

- Rich in iron (40.0 ppm) and zinc (40.6 ppm) in comparison to 28.0-32.0 ppm iron and 30.0-32.0 ppm zinc in popular varieties
- Grain yield: 51.7 q/ha
- Maturity: 141 days
- Suitable for irrigated timely sown conditions in *rabi*
- Adaptation: Punjab, Haryana, Delhi, Rajasthan (excluding Kota & Udaipur division), Western Uttar Pradesh (except Jhansi division), Jammu and Kathua district of Jammu & Kashmir, Paonta Valley and Una district of Himachal Pradesh and Tarai region of Uttarakhand
- Developed by Punjab Agricultural University, Ludhiana under ICAR-All India Coordinated Research Project on Wheat & Barley

Year of release: 2017

Wheat: Pusa Tejas (HI 8759) durum

(Pure line variety)

Protein 12.0 %

Iron 41.1 ppm

Zinc 42.8 ppm

- Rich in protein (12.0 %), iron (41.1 ppm) and zinc (42.8 ppm) in comparison to 8-10 % protein, 28.0-32.0 ppm iron and 30.0-32.0 ppm zinc in popular varieties
- Grain yield: 57.0 q/ha
- Maturity: 117 days
- Suitable for irrigated timely sown conditions in *rabi*
- Adaptation: Madhya Pradesh, Chhattisgarh, Gujarat, Rajasthan (Kota & Udaipur Division) and Uttar Pradesh (Jhansi Division)
- Developed by ICAR-Indian Agricultural Research Institute, Regional Station, Indore

Year of release: 2017

Wheat: Pusa Ujala (HI 1605)

(Pure line variety)

Protein 13.0 %

Iron 43.0 ppm

- Rich in protein (13.0 %) and iron (43.0 ppm) in comparison to 8-10 % protein and 28.0-32.0 ppm iron in popular varieties
- Grain yield: 30.0 q/ha
- Maturity: 105 days
- Suitable for timely sown restricted irrigated conditions in *rabi*
- Adaptation: Maharashtra and Karnataka
- Developed by ICAR-Indian Agricultural Research Institute, Regional Station, Indore

Year of release: 2017

Wheat: HD 3171

(Pure line variety)

Zinc 47.1 ppm

- Rich in zinc (47.1 ppm) in comparison to 30.0-32.0 ppm in popular varieties
- Grain yield: 28.0 q/ha
- Maturity: 122 days
- Suitable for timely sown rainfed conditions in *rabi*
- Adaptation: Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Assam and plains of North Eastern States
- Developed by ICAR-Indian Agricultural Research Institute, New Delhi

Year of release: 2017

Wheat: HI 8777 (durum)

(Pure line variety)

Iron
48.7 ppm

Zinc
43.6 ppm

- Rich in iron (48.7 ppm) and zinc (43.6 ppm) in comparison to 28.0-32.0 ppm iron and 30.0-32.0 ppm zinc in popular varieties
- Grain yield: 18.5 q/ha
- Maturity: 108 days
- Suitable for timely sown rainfed conditions in *rabi*
- Adaptation: Maharashtra, Karnataka and plains of Tamil Nadu
- Developed by ICAR-Indian Agricultural Research Institute, Regional Station, Indore

Year of release: 2018

Wheat: MACS 4028 (durum)

(Pure line variety)

Protein 14.7 %

Iron 46.1 ppm

Zinc 40.3 ppm

- Rich in protein (14.7 %), iron (46.1 ppm) and zinc (40.3 ppm) in comparison to 8-10 % protein, 28.0-32.0 ppm iron and 30.0-32.0 ppm zinc in popular varieties
- Grain yield: 19.3 q/ha
- Maturity: 102 days
- Suitable for rainfed, low fertility, timely sown conditions in *rabi*
- Adaptation: Maharashtra and Karnataka
- Developed by Agharkar Research Institute, Pune under ICAR-All India Coordinated Research Project on Wheat & Barley

Year of release: 2018

Wheat: PBW 752

(Pure line variety)

Protein 12.4 %

- Rich in protein (12.4 %) in comparison to 8-10 % in popular varieties
- Grain yield: 49.7 q/ha
- Maturity: 120 days
- Suitable for late sown irrigated conditions in *rabi*
- Adaptation: Punjab, Haryana, Delhi, Rajasthan (excluding Kota & Udaipur division), Western Uttar Pradesh (except Jhansi division), Jammu and Kathua district of Jammu & Kashmir, Paonta Valley and Una district of Himachal Pradesh and Tarai region of Uttarakhand
- Developed by Punjab Agricultural University, Ludhiana under ICAR-All India Coordinated Research Project on Wheat & Barley

Year of release: 2018

Wheat: PBW 757

(Pure line variety)

Zinc 42.3 ppm

- Contains high zinc (42.3 ppm) in comparison to 30.0-32.0 ppm zinc in popular varieties
- Grain yield: 36.7 q/ha
- Maturity: 104 days
- Suitable for very late sown irrigated conditions in *rabi*
- Adaptation: Punjab, Haryana, Delhi, Rajasthan (excluding Kota & Udaipur division), Western Uttar Pradesh (except Jhansi division), Jammu and Kathua district of Jammu & Kashmir, Paonta Valley and Una district of Himachal Pradesh and Tarai region of Uttarakhand
- Developed by Punjab Agricultural University, Ludhiana under ICAR-All India Coordinated Research Project on Wheat & Barley

Year of release: 2018

Wheat: Karan Vandana (DBW 187)

(Pure line variety)

Iron
43.1 ppm

- Rich in iron (43.1 ppm) in comparison to 28.0-32.0 ppm in popular varieties
- Grain yield: 48.8 q/ha North Eastern Plains Zone (NEPZ), 61.3q/ha North Western Plains Zone (NWPZ), 75.5q/ha (High fertility)
- Maturity: 120 days (NEPZ), 146 days (NWPZ) & 158 days (High fertility)
- Suitable for timely sown irrigated and fertlity conditions in *rabi*
- Adaptation: Punjab, Haryana, Delhi, Rajasthan (excluding Kota & Udaipur division), Uttar Pradesh (except Jhansi division), Jammu and Kathua district of Jammu & Kashmir, Paonta Valley and Una district of Himachal Pradesh, Tarai region of Uttarakhand, Bihar, Jharkhand, Odisha, West Bengal, Assam and Plains of North Eastern states.
- Developed by ICAR-Indian Institute of Wheat & Barley Research, Karnal

Year of release: 2018 & 2020

Wheat: DBW 173

(Pure line variety)

Protein 12.5 %

Iron 40.7 ppm

- Rich in protein (12.5 %) and iron (40.7 ppm) in comparison to 8-10 % protein and 28.0-32.0 ppm iron in popular varieties
- Grain yield: 47.2 q/ha
- Maturity: 122 days
- Suitable for late sown irrigated conditions in *rabi*
- Adaptation: Punjab, Haryana, Delhi, Rajasthan (excluding Kota & Udaipur division), Western Uttar Pradesh (except Jhansi division), Jammu and Kathua district of Jammu & Kashmir, Paonta Valley and Una district of Himachal Pradesh and Tarai region of Uttarakhand
- Developed by ICAR-Indian Institute of Wheat & Barley Research, Karnal

Year of release: 2018

Wheat: UAS 375

(Pure line variety)

Protein 13.8 %

- Rich in protein (13.8 %) in comparison to 8-10 % in popular varieties
- Grain yield: 21.4 q/ha
- Maturity: 103 days
- Suitable for timely sown rainfed conditions in *rabi*
- Adaptation: Maharashtra and Karnataka
- Developed by University of Agricultural Sciences, Dharwad under ICAR-All India Coordinated Research Project on Wheat & Barley

Year of release: 2018

Wheat: DDW 47

(Pure line variety)

Protein 12.7 %

Iron 40.1 ppm

- Rich in protein (12.7 %) and iron (40.1 ppm) in comparison to 8-10 % protein and 28.0-32.0 ppm iron in popular varieties
- Grain yield: 37.3 q/ha
- Maturity: 121 days
- Suitable for timely sown restricted irrigated conditions in *rabi*
- Adaptation: Madhya Pradesh, Gujarat, Rajasthan and Chhattisgarh
- Developed by ICAR-Indian Institute of Wheat & Barley Research, Karnal

Year of release: 2020

Wheat: PBW 771

(Pure line variety)

Zinc 41.4 ppm

- Rich in zinc (41.4 ppm) in comparison to 30.0-32.0 ppm in popular varieties
- Grain yield: 50.3 q/ha
- Maturity: 120 days
- Suitable for late sown irrigated conditions in *rabi*
- Adaptation: Punjab, Haryana, Delhi, Rajasthan (excluding Kota & Udaipur division), Western Uttar Pradesh (except Jhansi divisions), Jammu and Kathua districts of Jammu & Kashmir, Paonta Valley and Una district of Himachal Pradesh and Tarai region of Uttarakhand
- Developed by Punjab Agricultural University, Ludhiana under ICAR-All Indian Coordinated Research Project on Wheat & Barley

Year of release: 2020

Wheat: HI 8802 (durum)

(Pure line variety)

Protein 13.0 %

- Rich in protein (13.0 %) in comparison to 8-10 % in popular varieties
- Grain yield: 29.1 q/ha
- Maturity: 109 days
- Suitable for timely sown rainfed conditions in *rabi*
- Adaptation: Maharashtra, Karnataka and plains of Tamil Nadu
- Developed by ICAR-Indian Agricultural Research Institute, Regional Station, Indore

Year of release: 2020

Wheat: HI 8805 (durum)

(Pure line variety)

Protein 12.8 %

Iron 40.4 ppm

- Rich in protein (12.8 %) and iron (40.4 ppm) in comparison to 8-10 % protein and 28.0-32.0 ppm iron in popular varieties
- Grain yield: 30.4 q/ha
- Maturity: 105 days
- Suitable for timely sown rainfed conditions in *rabi*
- Adaptation: Maharashtra, Karnataka and plains of Tamil Nadu
- Developed by ICAR-Indian Agricultural Research Institute, Regional Station, Indore

Year of release: 2020

Wheat: HD 3249

(Pure line variety)

Iron
42.5 ppm

- Rich in iron (42.5 ppm) in comparison to 28.0-32.0 ppm in popular varieties
- Grain yield: 48.8 q/ha
- Maturity: 122 days
- Suitable for timely sown irrigated conditions in *rabi*
- Adaptation: Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal (excluding Hills), Odisha, Assam and plains of North Eastern States
- Developed by ICAR-Indian Agricultural Research Institute, New Delhi

Year of release: 2020

Wheat: MACS 4058 (durum)

(Pure line variety)

Protein 14.7 %

Iron 39.5 ppm

Zinc 37.8 ppm

- Rich in protein (14.7 %), iron (39.5 ppm) and zinc (37.8 ppm) in comparison to 8-10 % protein, 28.0-32.0 ppm iron and 30.0-32.0 ppm zinc in popular varieties
- Grain yield: 29.6 q/ha
- Maturity: 102 days
- Suitable for timely sown restricted irrigated conditions in *rabi*
- Adaptation: Maharashtra and Karnataka
- Developed by Agharkar Research Institute, Pune under ICAR-All India Coordinated Research Project on Wheat & Barley

Year of release: 2020

Wheat: HD 3298

(Pure line variety)

Protein 12.1 %

Iron 43.1 ppm

- Rich in protein (12.1 %) and iron (43.1 ppm) in comparison to 8-10 % protein and 28.0-32.0 ppm iron in popular varieties
- Grain yield: 43.7 q/ha
- Maturity: 103 days
- Suitable for very late sown irrigated conditions in *rabi*
- Adaptation: Punjab, Haryana, Delhi, Rajasthan (except Kota & Udaipur Divisions), Western Uttar Pradesh (except Jhansi Division), Parts of Jammu & Kashmir (Jammu & Kathua district), Parts of Himachal Pradesh (Una district & Paonta Valley) and Uttarakhand (Tarai region)
- Developed by ICAR-Indian Agricultural Research Institute, New Delhi

Year of release: 2020

Wheat: HI 1633

(Pure line variety)

Protein 12.4 %

Iron 41.6 ppm

Zinc 41.1 ppm

- Rich in protein (12.4 %), iron (41.6 ppm) and zinc (41.1 ppm) in comparison to 8-10 % protein, 28.0-32.0 ppm iron and 30.0-32.0 ppm zinc in popular varieties
- Grain yield: 41.7 q/ha
- Maturity: 100 days
- Suitable for late sown irrigated conditions in *rabi*
- Adaptation: Maharashtra, Karnataka and plains of Tamil Nadu
- Developed by ICAR-Indian Agricultural Research Institute, Regional Station, Indore

Year of release: 2020

Wheat: DBW 303

(Pure line variety)

Protein 12.1 %

- Rich in protein (12.1 %) in comparison to 8-10 % protein in popular varieties
- Grain yield: 81.2 q/ha
- Maturity: 156 days
- Suitable for irrigated early sown and high fertility conditions in *rabi*
- Adaptation: Punjab, Haryana, Delhi, Rajasthan (except Kota & Udaipur divisions) and Western Uttar Pradesh (except Jhansi division), parts of Jammu & Kashmir (Jammu & Kathua districts) and parts of Himachal Pradesh (Una district & Paonta valley) and Uttaranchal (Tarai region)
- Developed by ICAR-Indian Institute of Wheat & Barley Research, Karnal

Year of release: 2020

Wheat: DDW 48 (durum)

(Pure line variety)

Protein 12.1 %

- Rich in protein (12.1 %) in comparison to 8-10 % protein in popular varieties
- Grain yield: 47.4 q/ha
- Maturity: 111 days
- Suitable for timely sown irrigated conditions in *rabi*
- Adaptation: Maharashtra, Karnataka and plains of Tamil Nadu
- Developed by ICAR-Indian Institute of Wheat & Barley Research, Karnal

Year of release: 2020

Maize: Vivek QPM 9

(Hybrid)

Lysine 4.19 %

Tryptophan 0.83 %

- Rich in lysine (4.19 % in protein) and tryptophan (0.83 % in protein) in comparison to 1.5-2.0 % lysine and 0.3-0.4 % tryptophan in popular hybrids
- Grain yield: 52.0 q/ha
- Maturity: 88 days
- Adaptation: *Kharif* season in Jammu & Kashmir, Himachal Pradesh, Uttarakhand (Hill region), North Eastern states, Maharashtra, Karnataka, Andhra Pradesh, Telangana and Tamil Nadu
- Developed by ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora

Year of release: 2008

Maize: Pusa HM4 Improved

(Hybrid)

Lysine 3.62 %

Tryptophan 0.91 %

- Rich in lysine (3.62 % in protein) and tryptophan (0.91 % in protein) in comparison to 1.5-2.0 % lysine and 0.3-0.4 % tryptophan in popular hybrids
- Grain yield: 64.2 q/ha
- Maturity: 87 days
- Adaptation: *Kharif* season in Punjab, Haryana, Delhi, Uttarakhand (plains) and Uttar Pradesh (Western region)
- Developed by ICAR-Indian Agricultural Research Institute, New Delhi

Year of release: 2017

Maize: Pusa HM8 Improved

(Hybrid)

Lysine 4.18 %

Tryptophan 1.06 %

- Rich in lysine (4.18 % in protein) and tryptophan (1.06 % in protein) in comparison to 1.5-2.0 % lysine and 0.3-0.4 % tryptophan in popular hybrids
- Grain yield: 62.6 q/ha
- Maturity: 95 days
- Adaptation: *Kharif* season in Maharashtra, Karnataka, Andhra Pradesh, Telangana and Tamil Nadu
- Developed by ICAR-Indian Agricultural Research Institute, New Delhi

Year of release: 2017

Maize: Pusa HM9 Improved

(Hybrid)

Lysine 2.97 %

Tryptophan 0.68 %

- Rich in lysine (2.97 % in protein) and tryptophan (0.68 % in protein) in comparison to 1.5-2.0 % lysine and 0.3-0.4 % tryptophan in popular hybrids
- Grain yield: 52.0 q/ha
- Maturity: 89 days
- Adaptation: *Kharif* season in Bihar, Jharkhand, Odisha, Uttar Pradesh (Eastern region) and West Bengal
- Developed by ICAR-Indian Agricultural Research Institute, New Delhi

Year of release: 2017

Maize: Pusa Vivek QPM9 Improved

(Hybrid)

Provitamin-A 8.15 ppm

Lysine 2.67 %

Tryptophan 0.74%

- Country's first provitamin-A rich maize
- Rich in provitamin-A (8.15 ppm), lysine (2.67 % in protein) and tryptophan (0.74 % in protein) in comparison to 1.0-2.0 ppm provitamin-A, 1.5-2.0 % lysine and 0.3-0.4 % tryptophan in popular hybrids
- Grain yield: 55.9 q/ha [Northern Hills Zone (NHZ)] and 59.2 q/ha [Peninsular Zone (PZ)]
- Maturity: 93 days (NHZ) and 83 days (PZ)
- Adaptation: *Kharif* season in Jammu & Kashmir, Himachal Pradesh, Uttarakhand (Hill region), North Eastern states, Maharashtra, Karnataka, Andhra Pradesh, Telangana and Tamil Nadu
- Developed by ICAR-Indian Agricultural Research Institute, New Delhi

Year of release: 2017

Maize: Pusa VH 27 Improved

(Hybrid)

Provitaim-A 5.49 ppm

- Rich in provitamin-A (5.49 ppm) in comparison to 1.0-2.0 ppm provitamin-A in popular hybrids
- Grain yield: 48.5 q/ha
- Maturity: 84 days
- Adaptation: *Kharif* season in Bihar, Jharkhand, Odisha, Uttar Pradesh (Eastern region) and West Bengal
- Developed by ICAR-Indian Agricultural Research Institute, New Delhi

Year of release: 2020

Maize: Pusa HQPM 5 Improved

(Hybrid)

Provitamin-A 6.77 ppm

Lysine 4.25%

Tryptophan 0.94%

- Rich in provitamin-A (6.77 ppm), lysine (4.25 % in protein) and tryptophan (0.94 % in protein) in comparison to 1.0-2.0 ppm provitamin-A, 1.5-2.0 % lysine and 0.3-0.4 % tryptophan in popular hybrids
- Grain yield: 72.6 q/ha (NHZ), 75.1 q/ha (NWPZ), 53.5 q/ha (NEPZ), 71.2 q/ha (PZ) and 51.2 q/ha (CWZ)
- Maturity: 111 days (NHZ), 92 days (NWPZ), 88 days (NEPZ), 98 days (PZ) and 91 days (CWZ)
- Adaptation: *Kharif* season across the country
- Developed by ICAR-Indian Agricultural Research Institute, New Delhi

Year of release: 2020

Maize: Pusa HQPM 7 Improved

(Hybrid)

Provitamin-A 7.10 ppm

Lysine 4.19%

Tryptophan 0.93%

- Rich in provitamin-A (7.10 ppm), lysine (4.19 % in protein) and tryptophan (0.93 % in protein) in comparison to 1.0-2.0 ppm provitamin-A, 1.5-2.0 % lysine and 0.3-0.4 % tryptophan in popular hybrids
- Grain yield: 74.5 q/ha
- Maturity: 97 days
- Adaptation: *Kharif* season in Maharashtra, Karnataka, Andhra Pradesh, Telangana and Tamil Nadu
- Developed by ICAR-Indian Agricultural Research Institute, New Delhi

Year of release: 2020

Maize: IQMH 201 (LQMH 1)

(Hybrid)

Lysine 3.03 %

Tryptophan 0.73 %

- Rich in lysine (3.03 % in protein) and tryptophan (0.73 % in protein) in comparison to 1.5-2.0 % lysine and 0.3-0.4 % tryptophan in popular hybrids
- Grain yield: 84.8 q/ha
- Maturity: 101 days
- Adaptation: *Kharif* season in Jammu & Kashmir, Himachal Pradesh, Uttarakhand and North Eastern states
- Developed by ICAR-Indian Institute of Maize Research, Ludhiana

Year of release: 2020

Maize: IQMH 202 (LQMH 2)

(Hybrid)

Lysine 3.04 %

Tryptophan 0.66 %

- Rich in lysine (3.04 % in protein) and tryptophan (0.66 % in protein) in comparison to 1.5-2.0 % lysine and 0.3-0.4 % tryptophan in popular hybrids
- Grain yield: 72.0 q/ha
- Maturity: 96 days
- Adaptation: *Kharif* season in Punjab, Haryana, Delhi, western Uttar Pradesh and plains of Uttarakhand
- Developed by ICAR-Indian Institute of Maize Research, Ludhiana

Year of release: 2020

Maize: IQMH 203 (LQMH 3)

(Hybrid)

Lysine 3.48 %

Tryptophan 0.77 %

- Rich in lysine (3.48 % in protein) and tryptophan (0.77 % in protein) in comparison to 1.5-2.0 % lysine and 0.3-0.4 % tryptophan in popular hybrids
- Grain yield: 63.0 q/ha
- Maturity: 90 days
- Adaptation: *Kharif* season in Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh
- Developed by ICAR-Indian Institute of Maize Research, Ludhiana

Year of release: 2020

Pearl Millet: HHB 299

(Hybrid)

Iron 73.0 ppm

Zinc 41.0 ppm

- Rich in iron (73.0 ppm) and zinc (41.0 ppm) in comparison to 45.0-50.0 ppm iron and 30.0-35.0 ppm zinc in popular varieties/hybrids
- Grain yield: 32.7 q/ha
- Dry fodder yield: 73.0 q/ha
- Maturity: 81 days
- Adaptation: *Kharif* season in Haryana, Rajasthan, Gujarat, Punjab, Delhi, Maharashtra and Tamil Nadu
- Developed by CCS-Haryana Agricultural University, Hisar in collaboration with ICRISAT, Patancheru under ICAR-All India Coordinated Research Project on Pearl Millet

Year of release: 2017

Pearl Millet: AHB 1200Fe

(Hybrid)

Iron
73.0 ppm

- Rich in iron (73.0 ppm) in comparison to 45.0-50.0 ppm in popular varieties/hybrids
- Grain yield: 32.0 q/ha
- Dry fodder yield: 70.0 q/ha
- Maturity: 78 days
- Adaptation: *Kharif* season in Haryana, Rajasthan, Gujarat, Punjab, Delhi, Maharashtra and Tamil Nadu
- Developed by Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani in collaboration with ICRISAT, Patancheru under ICAR-All India Coordinated Research Project on Pearl Millet

Year of release: 2018

Pearl Millet: AHB 1269Fe

(Hybrid)

Iron 91.0 ppm

Zinc 43.0 ppm

- Rich in iron (91.0 ppm) and zinc (43.0 ppm) in comparison to 45.0-50.0 ppm iron and 30.0-35.0 ppm zinc in popular varieties/hybrids
- Grain yield: 31.7 q/ha
- Dry fodder yield: 74.0 q/ha
- Maturity: 82 days
- Adaptation: *Kharif* season in Gujarat, Haryana, Punjab, Delhi, Maharashtra, Telangana and Tamil Nadu
- Developed by Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani under ICAR-All India Coordinated Research Project on Pearl Millet

Year of release: 2018

Pearl Millet: ABV 04

(Open Pollinated Variety)

Iron 70.0 ppm

Zinc 63.0 ppm

- Rich in iron (70.0 ppm) and zinc (63.0 ppm) in comparison to 45.0-50.0 ppm iron and 30.0-35.0 ppm zinc in popular varieties/hybrids
- Grain yield: 28.6 q/ha
- Dry fodder yield: 58.0 q/ha
- Maturity: 86 days
- Adaptation: *Kharif* season in Maharashtra, Karnataka, Andhra Pradesh, Telangana and Tamil Nadu
- Developed by ARS, Acharya NG Ranga Agricultural University, Ananthapuramu under ICAR-All India Coordinated Research Project on Pearl Millet

Year of release: 2018

Pearl Millet: Phule Mahashakti

(Hybrid)

Iron 87.0 ppm

Zinc 41.0 ppm

- Rich in iron (87.0 ppm) and zinc (41.0 ppm) in comparison to 45.0-50.0 ppm iron and 30.0-35.0 ppm zinc in popular varieties/hybrids
- Grain yield: 29.3 q/ha
- Dry fodder yield: 56.0 q/ha
- Maturity: 88 days
- Adaptation: *Kharif* season in Maharashtra
- Developed by Mahatma Phule Krishi Vidyapeeth, Dhule under ICAR-All India Coordinated Research Project on Pearl Millet

Year of release: 2018

Pearl Millet: RHB 233

(Hybrid)

Iron 83.0 ppm

Zinc 46.0 ppm

- Rich in iron (83.0 ppm) and zinc (46.0 ppm) in comparison to 45.0-50.0 ppm iron and 30.0-35.0 ppm zinc in popular varieties/hybrids
- Grain yield: 31.6 q/ha
- Dry fodder yield: 74.0 q/ha
- Maturity: 80 days
- Adaptation: *Kharif* season in Rajasthan, Gujarat, Haryana, Madhya Pradesh, Delhi, Maharashtra and Tamil Nadu
- Developed by Sri Karan Narendra Agricultural University, Jobner under ICAR-All India Coordinated Research Project on Pearl millet

Year of release: 2019

Pearl Millet: RHB 234

(Hybrid)

Iron 84.0 ppm

Zinc 46.0 ppm

- Rich in iron (84.0 ppm) and zinc (46.0 ppm) in comparison to 45.0-50.0 ppm iron and 30.0-35.0 ppm zinc in popular varieties/hybrids
- Grain yield: 31.7 q/ha
- Dry fodder yield: 70.0 q/ha
- Maturity: 81 days
- Adaptation: *Kharif* season in Rajasthan, Gujarat, Haryana, Madhya Pradesh, Delhi, Maharashtra and Tamil Nadu
- Developed by Sri Karan Narendra Agricultural University, Jobner under ICAR-All India Coordinated Research Project on Pearl millet

Year of release: 2019

Pearl Millet: HHB 311

(Hybrid)

Iron
83.0 ppm

- Rich in iron (83.0 ppm) in comparison to 45.0-50.0 ppm in popular varieties/hybrids
- Grain yield: 31.7 q/ha
- Dry fodder yield: 72.0 q/ha
- Maturity: 81 days
- Adaptation: *Kharif* season in Rajasthan, Gujarat, Haryana, Punjab, Delhi, Maharashtra and Tamil Nadu
- Developed by CCS Haryana Agricultural University, Hisar under ICAR-All India Coordinated Research Project on Pearl millet

Year of release: 2020

Finger Millet: VR 929 (Vegavathi)

(Pure line variety)

Iron
131.8 ppm

- Rich in iron (131.8 ppm) in comparison to 25.0 ppm in popular varieties
- Grain yield: 36.1 q/ha
- Dry fodder yield: 72.0 q/ha
- Maturity: 118 days
- Adaptation: *Kharif* season across country
- Developed by Acharya NG Ranga Agricultural University, Guntur under ICAR-All India Coordinated Research Project on Small Millets

Year of release: 2020

Finger Millet: CFMV1 (Indravati)

(Pure line variety)

Calcium 428 mg/100g

Iron 58.0 ppm

Zinc 44.0 ppm

- Rich in calcium (428 mg/100g), iron (58.0 ppm) and zinc (44.0 ppm) in comparison to 200 mg/100g calcium, 25 ppm iron and 16 ppm zinc in popular varieties
- Grain yield: 31.1 q/ha
- Dry fodder yield: 84.4 q/ha
- Maturity: 110-115 days
- Suitable for rainfed condition
- Adaptation: *Kharif* season in Andhra Pradesh, Tamil Nadu, Karnataka, Puducherry and Odisha
- Developed by ARS, ANGRAU, Vizianagaram under ICAR-All India Coordinated Research Project on Small Millets

Year of release: 2020

Finger Millet: CFMV 2

(Pure line variety)

Calcium
454 mg/100g

Iron
39.0 ppm

Zinc
25.0 ppm

- Rich in calcium (454 mg/100g), iron (39.0 ppm) and zinc (25.0 ppm) in comparison to 200 mg/100g calcium, 25 ppm iron and 16 ppm zinc in popular varieties
- Grain yield: 29.5 q/ha
- Dry fodder yield: 86.1 q/ha
- Maturity: 119-121 days
- Suitable for rainfed condition
- Adaptation: *Kharif* season in Andhra Pradesh, Chhattisgarh, Gujarat, Maharashtra and Odisha
- Developed by Hill Millet Research Station, Navsari Agricultural University, Waghai under ICAR-All India Coordinated Research Project on Small Millets

Year of release: 2020

Little Millet: CLMV1

(Pure line variety)

Iron 59.0 ppm

Zinc 35.0 ppm

- Rich in iron (59.0 ppm) and zinc (35.0 ppm) in comparison to 25 ppm iron and 20 ppm zinc in popular varieties
- Grain yield: 15.8 q/ha
- Dry fodder yield: 55.5 q/ha
- Maturity: 98-102 days
- Suitable for rainfed condition
- Adaptation: *Kharif* season in Maharashtra, Andhra Pradesh, Telangana, Tamil Nadu and Puducherry
- Developed by ICAR-Indian Institute of Millets Research, Hyderabad

Year of release: 2020

Lentil: Pusa Ageti Masoor

(Pure line variety)

Iron
65.0 ppm

- Rich in iron (65.0 ppm) in comparison to 45.0-50.0 ppm in popular varieties
- Grain yield: 13.0 q/ha
- Maturity: 100 days
- Medium seed with orange cotyledon
- Suitable for rainfed condition
- Adaptation: *Rabi* season in Uttar Pradesh, Madhya Pradesh and Chhattisgarh
- Developed by ICAR-Indian Agricultural Research Institute, New Delhi

Year of release: 2017

Lentil: IPL 220

(Pure line variety)

Iron 73.0 ppm

Zinc 51.0 ppm

- Rich in iron (73.0 ppm) and zinc (51.0 ppm) in comparison to 45.0-50.0 ppm iron and 35.0-40.0 ppm zinc in popular varieties
- Grain yield: 13.8 q/ha
- Maturity: 121 days
- Suitable for rainfed conditions
- Adaptation: *Rabi* season in Eastern Uttar Pradesh, Bihar, Assam and West Bengal
- Developed by ICAR-Indian Institute of Pulses Research, Kanpur

Year of release: 2018

Groundnut: Girnar 4

(Pure line variety)

Oleic acid 78.5 %

- Rich in oleic acid (78.5 % in oil) in comparison to 45-52% in popular varieties
- Oil content: 53.0 %
- Protein content: 27 %
- Pod yield: 32.2 q/ha
- Kernel yield: 21.3 q/ha
- Maturity: 112 days
- Adaptation: *Kharif* season in Rajasthan, Karnataka, Gujarat, Tamil Nadu and Andhra Pradesh
- Developed by ICAR-Directorate of Groundnut Research, Junagadh

Year of release: 2020

Groundnut: Girnar 5

(Pure line variety)

Oleic acid 78.4 %

- Rich in oleic acid (78.4 % in oil) in comparison to 45-52% in popular varieties
- Oil content: 53.0 %
- Protein content: 26 %
- Pod yield: 31.2 q/ha
- Kernel yield: 21.3 q/ha
- Maturity: 113 days
- Adaptation: *Kharif* season in Rajasthan, Karnataka, Gujarat, Tamil Nadu and Andhra Pradesh
- Developed by ICAR-Directorate of Groundnut Research, Junagadh

Year of release: 2020

Linseed: TL 99

(Pure line variety)

Linoleic acid (58.9%)

- High in linoleic acid (58.9%) compared to 20-25 % in traditional varieties
- Low in linolenic acid (4.1 % in oil) in comparison to >40.0 % in popular varieties
- Oil content: 36.6 %
- Seed yield: 12.7 q/ha
- Maturity: 131 days
- Suitable for irrigated conditions
- Adaptation: *Rabi* season in Uttar Pradesh, Bihar, Jharkhand, West Bengal, Assam and Nagaland
- Developed by Bhabha Atomic Research Centre, Mumbai under ICAR-All India Coordinated Research Project on Linseed

Year of release: 2019

Mustard: Pusa Mustard 30

(Pure line variety)

Erucic acid 1.20 %

- Low in erucic acid (1.20 % in oil) in comparison to >40.0 % in popular varieties
- Oil content: 37.7 %
- Seed yield: 18.2 q/ha
- Maturity: 137 days
- Suitable for timely sown irrigated conditions
- Adaptation: *Rabi* season in Uttar Pradesh, Chhatisgarh, Uttarakhand, Madhya Pradesh and Rajasthan
- Developed by ICAR-Indian Agricultural Research Institute, New Delhi

Year of release: 2013

Mustard: Pusa Double Zero Mustard 31

(Pure line variety)

Erucic acid 0.76 %

Glucosinolates 29.41 ppm

- Country's first Canola Quality Indian mustard variety
- Low in erucic acid (0.76 % in oil) and glucosinolates (29.41 ppm in seed meal) in comparison to >40.0 % erucic acid and >120.0 ppm glucosinolates in popular varieties
- Oil content: 41.0 %
- Seed yield: 23.0 q/ha
- Maturity: 142 days
- Suitable for timely sown irrigated conditions
- Adaptation: *Rabi* season in Rajasthan (North and Western parts), Punjab, Haryana, Delhi, Western Uttar Pradesh Plains of Jammu & Kashmir and Himachal Pradesh
- Developed by ICAR-Indian Agricultural Research Institute, New Delhi

Year of release: 2016

Mustard: Pusa Mustard 32

(Pure line variety)

Erucic acid 1.32 %

- Low in erucic acid (1.32 % in oil) in comparison to >40.0 % in popular varieties
- Oil content: 38.0 %
- Seed yield: 27.1 q/ha
- Maturity: 145 days
- Suitable for timely sown irrigated conditions
- Adaptation: *Rabi* season in Rajasthan (northern and western parts), Punjab, Haryana, Delhi, Western Uttar Pradesh, plains of Jammu & Kashmir and Himachal Pradesh
- Developed by ICAR-Indian Agricultural Research Institute, New Delhi

Year of release: 2020

Soybean: NRC 127

(Pure line variety)

Kunitz Tryptsin Inhibitor Free

- Country's first Kunitz Trypsin Inhibitor (KTI) free variety
- Free from KTI in comparison to 30-45 mg/g of seed meal in popular varieties
- Oil content: 19.1 %
- Protein content: 39.0 %
- Grain yield: 18.0 q/ha
- Maturity: 104 days
- Adaptation: *Kharif* season in Madhya Pradesh, Bundelkhand region of Uttar Pradesh, Rajasthan, Gujarat and Marathwada and Vidarbha region of Maharashtra
- Developed by ICAR-Indian Institute of Soybean Research, Indore

Year of release: 2018

Soybean: NRC 132

(Pure line variety)

Lipoxigenase-2 free

- Free from lipoxygenase-2
- Less beany flavour, suitable for making soybean milk and other products
- Grain yield: 22.9 q/ha Southern zone (SZ) and 16.5 q/ha Eastern zone (EZ)
- Maturity: 99 days (SZ) and 105 days (EZ)
- Adaptation: *Kharif* season in West Bengal, Bihar, Jharkhand, Chhattisgarh, Odisha, Southern Maharashtra, Karnataka, Telangana, Andhra Pradesh and Tamil Nadu
- Developed by ICAR-Indian Institute of Soybean Research, Indore

Year of release: 2020

Soybean: NRC 147

(Pure line variety)

Oleic acid 42.0%

- Rich in oleic acid (42.0%) in comparison to 22-25 % in popular varieties
- Grain yield: 23.6 q/ha [Southern zone (SZ)] and 14.0 q/ha [Eastern zone (EZ)]
- Maturity: 96 days (SZ) and 100 days (EZ)
- Adaptation: *Kharif* season in West Bengal, Bihar, Jharkhand, Chhattisgarh, Odisha, Southern Maharashtra, Karnataka, Telangana, Andhra Pradesh and Tamil Nadu
- Developed by ICAR-Indian Institute of Soybean Research, Indore

Year of release: 2020

Cauliflower: Pusa Beta Kesari 1

(Pure line variety)

Provitamin-A 8.0-10.0 ppm

- Country's first provitamin-A rich cauliflower
- Rich in provitamin-A (8.0-10.0 ppm) in comparison to negligible content in popular varieties
- Curd yield: 40.0-50.0 t/ha
- Adaptation: Nation Capital Region of Delhi
- Developed by ICAR-Indian Agricultural Research Institute, New Delhi

Year of release: 2015

Potato: Kufri Manik

(Variety)

Anthocyanin 0.68 ppm

- Rich in anthocyanin (0.68 ppm) in comparison to negligible content in popular varieties
- High in antioxidants
- Tuber yield: 23.0 t/ha
- Maturity: 90-100 days
- Adaptation: Punjab, Eastern Uttar Pradesh, Bihar, West Bengal and Assam
- Developed by ICAR-Central Potato Research Institute, Shimla

Year of release: 2020

Potato: Kufri Neelkanth

(Variety)

Anthocyanin 1.0 ppm

- Rich in anthocyanin (1.0 ppm) in comparison to negligible content in popular varieties
- High in antioxidants
- Tuber yield: 36-38 t/ha
- Maturity: 90-100 days
- Adaptation: Punjab, Haryana and Uttar Pradesh
- Developed by ICAR-Central Potato Research Institute, Shimla

Year of release: 2020

Sweet Potato: Bhu Sona

(Variety)

Provitamin-A 14.0 mg/100g

- Rich in provitamin-A (14.0 mg/100g) in comparison to 2.0-3.0 mg/100g in popular varieties
- Tuber yield: 19.8 t/ha
- Dry matter: 27.0-29.0 %
- Starch: 20.0 %
- Total sugar: 2.0-2.4 %
- Adaptation: Odisha
- Developed by ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram

Year of release: 2017

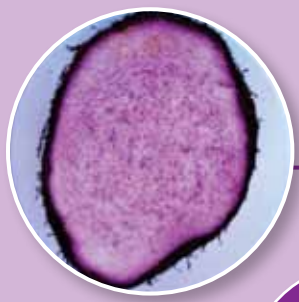
Sweet Potato: Bhu Krishna

(Variety)

Anthocyanin 90.0mg/100g

- Rich in anthocyanin (90.0 mg/100g) in comparison to negligible amount in popular varieties
- Tuber yield: 18.0 t/ha
- Dry matter: 24.0-25.5%
- Starch: 19.5 %
- Total sugar: 1.9-2.2 %
- Salinity stress tolerant
- Adaptation: Odisha
- Developed by ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram

Year of release: 2017



Greater Yam: Sree Neelima

(Variety)

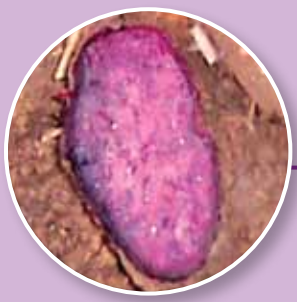
Anthocyanin 50 mg/100g

Protein 15.4 %

Zinc (49.8 ppm)

- Rich in anthocyanin (50.0 mg/100g), crude protein (15.4 %) and zinc (49.8 ppm) in comparison to negligible anthocyanin, 2.7 % crude protein and 22-32 ppm zinc in popular varieties
- Tuber yield: 35.0 t/ha
- Maturity: 240-270 days
- Adaptation: Kerala
- Developed by ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram

Year of release: 2020



Greater Yam: Da 340

(Variety)

Anthocyanin 141 .4 mg/100g

Iron 136.2 ppm

Calcium 1890 ppm

- Rich in anthocyanin (141.4 mg/100g), iron (136.2 ppm) and calcium (1890 ppm) in comparison to negligible anthocyanin, 70-120 ppm iron and 800-1200 ppm calcium in popular varieties
- Tuber yield: 80.0 t/ha
- Maturity: 240-270 days
- Adaptation: Kerala
- Developed by ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram

Year of release: 2020

Pomegranate: Solapur Lal

(Variety)

Iron 5.6-6.1 mg/100g

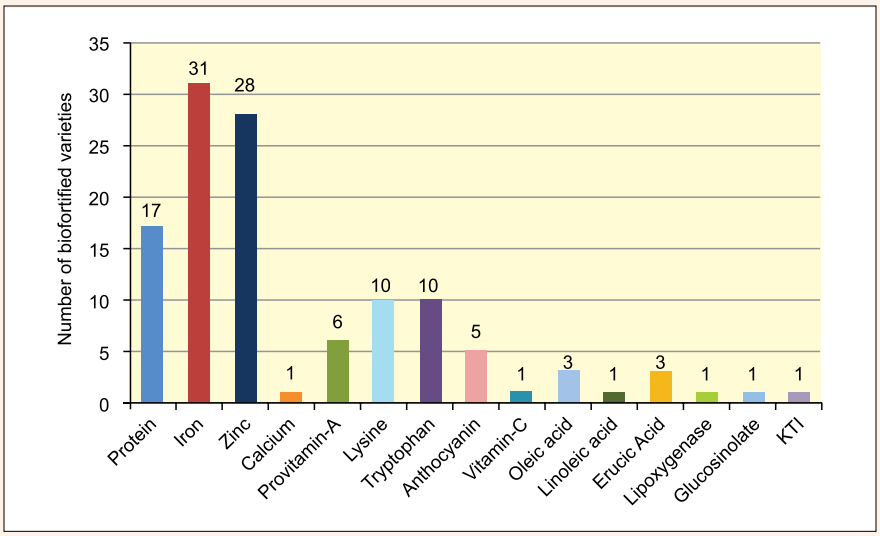
Zinc 0.64-0.69 mg/100g

Vitamin-C 19.4-19.8 mg/100g

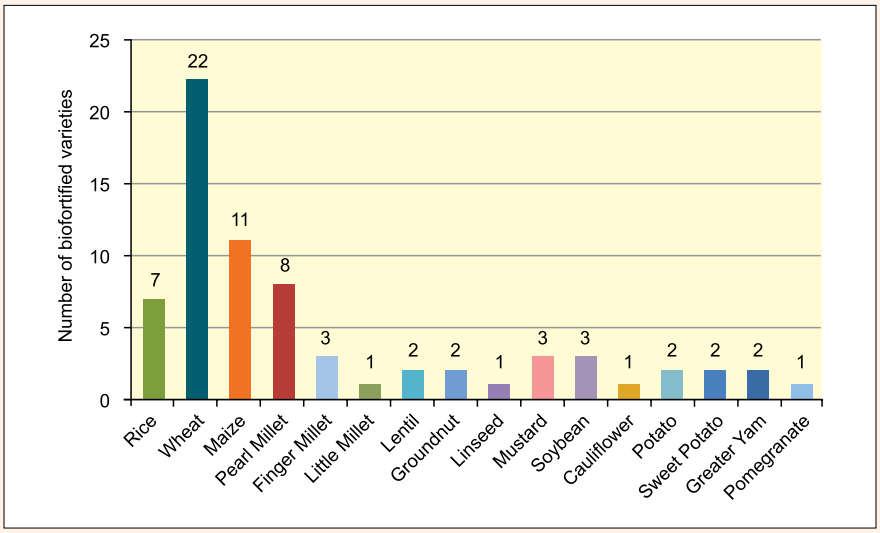
- Rich in iron (5.6-6.1 mg/100g), zinc (0.64-0.69 mg/100g) and vitamin-C (19.4-19.8 mg/100 g) in fresh arils in comparison to 2.7-3.2 mg/ 100g iron, 0.50-0.54 mg/100g zinc and 14.2-14.6 mg/100g vitamin-C in popular variety 'Ganesh'.
- Fruit yield: 23.0-27.0 t/ha
- Adaptation: Semi-arid regions of the country
- Developed by ICAR-National Research Centre on Pomegranate, Pune

Year of release: 2017

Summary of biofortified varieties



Trait-wise biofortified varieties developed through breeding



Crop-wise biofortified varieties developed through breeding

Nutrients: Baseline & levels achieved

Significant improvement achieved in nutritional quality over the baseline values in different field and horticultural crops.

S. No.	Crop	Nutrient	Baseline levels	Levels achieved
Nutritional factor				
1.	Rice	Protein	7.0-8.0 %	>10.0 %
2.		Zinc	12.0-16.0 ppm	>20.0 ppm
3.		Protein	8-10 %	>12.0 %
4.	Wheat	Iron	28.0-32.0 ppm	>38.0 ppm
5.		Zinc	30.0-32.0 ppm	>37.0 ppm
6.	Maize	Provitamin-A	0.5-1.5 ppm	>5.0 ppm
7.		Lysine	1.5-2.0 %	>2.5 %
8.		Tryptophan	0.3-0.4 %	>0.6 %
9.	Pearl Millet	Iron	45.0-50.0 ppm	>70.0 ppm
10.		Zinc	30.0-35.0 ppm	>40.0 ppm
11.	Finger Millet	Iron	25.0 ppm	>38.0 ppm
12.		Zinc	16.0 ppm	>24.0 ppm
13.		Calcium	200.0 mg/100g	>400.0 mg/100g
14.	Small Millet	Iron	25 ppm	>55 ppm
15.		Zinc	20 ppm	>33 ppm
16.	Lentil	Iron	45.0-50.0 ppm	>62.0 ppm
17.		Zinc	35.0-40.0 ppm	>50.0 ppm
18.	Groundnut	Oleic acid	45.0-52.0 %	>70.0 %

Contd...

Nutrients: Baseline & levels achieved

S. No.	Crop	Nutrient	Baseline levels	Levels achieved
19.	Linseed	Linoleic acid	20-25 %	>58 %
20.	Cauliflower	Provitamin-A	Negligible	>8.0 ppm
21.	Potato	Anthocyanin	Negligible	>0.60 ppm
22.	Sweet Potato	Provitamin-A	2.0-3.0 mg/100 g	>13.0 mg/100 g
23.		Anthocyanin	Negligible	>80.0 mg/100g
Nutritional factor				
24.	Greater Yam	Anthocyanin	35-60 mg/100g	Negligible
25.		Iron	70-120 ppm	>135.0 ppm
26.		Zinc	22-32 ppm	>48.0 ppm
27.		Calcium	800-1200 ppm	>1800 ppm
28.	Pomegranate	Iron	2.7-3.2 mg/100g	>5.0 mg/100g
29.		Zinc	0.50-0.54 mg/100g	>0.6 mg/100g
30.		Vitamin-C	14.2-14.6 mg/100g	>19.0 mg/100g
Anti-nutritional factor				
31.	Mustard	Erucic acid	>40.0 %	<2.0 %
32.		Glucosinolates	>120.0 ppm	<30.0 ppm
33.	Soybean	Kunitz trypsin inhibitor	30-45 mg/g of seed meal	Negligible
34.		Lipoxygenase	High beany flavour	Low beany flavour

Breeder seed production

7466.43 q of breeder seeds have been produced as per the indents received from Department of Agricultural Cooperation and Farmers' Welfare.

S. No.	Name of variety	2016-17 (q)	2017-18 (q)	2018-19 (q)	2019-20 (q)	Total (q)
			Rice			
1.	CR Dhan 310	23.00	-	5.30	48.00	76.30
2.	DRR Dhan 45	42.00	1.80	-	5.95	49.75
3.	Zinco Rice MS	-	-	-	16.20	16.20
4.	CR Dhan 311	-	1.00	1.00	3.00	5.00
			Wheat			
5.	WB 02	152.95	605.30	155.50	445.00	1358.75
6.	HPBW 01	-	-	153.00	200.00	353.00
7.	Pusa Tejas	80.00	386.00	360.00	960.00	1786.00
8.	Pusa Ujala	52.00	80.50	194.40	120.00	446.90
9.	HD 3171	15.00	20.52	88.00	120.00	243.52
10.	PBW 752	-	-	-	84.00	84.00
11.	PBW 757	-	-	-	60.00	60.00
12.	Karan Vandana	-	-	647.22	1305.00	1952.22
13.	DBW 173	-	-	335.00	321.00	656.00

Breeder seed production

S. No.	Name of variety	2016-17 (q)	2017-18 (q)	2018-19 (q)	2019-20 (q)	Total (q)
14.	UAS 375	-	-	16.50	15.00	31.50
15.	WH 1184	-	-	-	84.00	84.00
16.	HD 3249	-	-	-	10.00	10.00
17.	DDW 47	-	-	-	35.00	35.00
18.	HI 8802	-	-	-	10.00	10.00
19.	HI 8805	-	-	-	10.00	10.00
			Pearl Millet			
20.	HHB 299	-	-	0.60	6.70	7.30
21.	AHB 1200	-	-	0.60	16.10	16.70
22.	ABV 04	-	-	-	0.35	0.35
23.	RHB 233	-	-	1.00	-	1.00
			Lentil			
24.	Pusa Ageti Masoor	-	27.50	40.80	26.00	94.30
25.	IPL 220	-	-	5.74	43.00	48.74
			Mustard			
26.	Pusa Mustard 30	4.00	5.10	6.40	7.00	22.50
27.	Pusa Double Zero Mustard 31	1.00	0.90	2.00	3.50	7.40
	Grand Total	**369.95**	**1128.62**	**2013.06**	**3954.80**	**7466.43**

Scaling-up through partnership

The biofortified varieties have been licensed to various private seed companies and farmers producers' organizations (FPOs)

S. No.	Crop	Name of variety	Name of the companies & FPOs
1.	Rice	DRR Dhan 45	(i) Max Yield Bio Gene (India) Pvt. Ltd. (ii) Subidha
		CR Dhan 310	(i) Areia Agrotech Pvt. Ltd.
2.	Wheat	DBW 173	54 private seed companies & FPOs
		DBW 187	163 private seed companies & FPOs
3.	Mustard	Pusa Mustard 30	(i) Malwa Enterprises, Punjab (ii) Arpan Seeds Pvt. Ltd., Rajasthan (iii) Ananya Seeds Pvt. Ltd., Delhi (iv) Ajeet Seeds, Aurangabad (v) Dinkar Seeds, Ahmedabad
		Pusa Double Zero Mustard 31	(i) Dinkar Seeds, Ahmedabad (ii) Patanjali Bioresearch Centre, Hardwar
4.	Soybean	NRC 127	(i) M/s Balnath Farmer Producer Co. Ltd, Nagpur, Maharashtra (ii) M/s Suminter India Organics Ltd, Mumbai, Maharashtra (iii) M/s Parthasarthi Naturals, Anantpur, Andhra Pradesh (iv) Chandrakanta A Deshmukh, Nanded, Maharashtra
5.	Pearl Millet	HHB 311	(i) M/s Sampoorna Seeds (P) Ltd., Adoni, Andhra Pradesh (ii) M/s Sri Laxmi Venkateswara Seeds, Kurnool, Andhra Pradesh
		HHB 299	(i) M/s Sampoorna Seeds (P) Ltd., Adoni, Andhra Pradesh (ii) M/s Sri Laxmi Venkateswara Seeds, Kurnool, Andhra Pradesh

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