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Impact of ICAR-CPRI Technologies on Potato in India

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1. Background

Potato the third most important food crop in terms of human consumption primarily because of its overwhelming popularity and potential for ensuring food security to ever-increasing population. China and India jointly contribute about 38% of total world production. The growth of potato in the world has been phenomenal during last six decades, though the area under potato decreased (22.1 to 19.2 million ha), production increased by nearly 40% (270.6 to 383 million tonnes). Total potato production in India increased from 34.7 million tonnes in the year 2008 to 53 million tonnes now; an increase of almost 53% in 10 years. Moreover, the sector is expected to grow at about 3% annual compounded growth rate in India by 2050. Per capita per day availability of potato is also continuously increasing and has crossed 26kg in the recent years due to record harvest of potato continuously. However, increasing cost of cultivation, especially farm inputs. Comparatively less price of fresh potato produce, stagnation in productivity, decreasing cultivable land area, more complex biotic and abiotic stresses, inadequate availability of quality seeds and variety, post-harvest losses, meager value addition, and the changing climate are posing serious threats to sustainable potato production and utilization. In this chapter, we have tried to analyse the impact of ICAR research on potato output in India and why it needs to be supported more aggressively.

- Potato is a starchy staple with a potential to yield 216 Megajoules/ha/day dietary energy which is about 1.78 times higher than the rice.
- India is still an under fed country with average dietary energy intake per person per day of 2,233 Kcal for rural India and 2,206 Kcal for urban India; average energy intake is projected to increase to 2,700 by 2050. Energy dense and high productive crop like potato would play an important role in achieving that target.
- The crop witnessed 9.19 times increase in area, 31.30 times increase in production and 3.40 times increase in productivity during 1949-50 to 2016-17. Indigenous potato varieties developed by the institute played an important role in this remarkable achievement.

2. Evolution of potato research in the country

Potato is an ideal example of new world crop that has been introduced into the country about 400 years ago but quickly became an integral part of our food habit. Potato has its origin in South America and it is believed that cultivated potato originated in South America, in the basin of Lake Titicaca on Peru-Bolivian borders. Following the conquest of Peru, the Spaniards introduced potatoes in Spain and further spread it to many European countries by the end of the 16^{th} century. In the early years of the 17^{th} century, most probably Portuguese sailors took potato in India; however, the Britishers introduced potato to the hills of North India where it flourished in the colonial home gardens. Potato cultivation was introduced in the Simla hills in 1828 and in Nilgiri hills in 1830. By late 18^{th} or early 19^{th} century, the potato was an important established vegetable crop in the hills and plains of India. However, till that time, potato cultivation in the country remained restricted and the entire Indian subcontinent contributed only less than 1% of world's potato area and production until 1941.

Prior to independence, about 38 European varieties of *S. tuberosum* spp. Tuberosum (earlier called *S. tuberosum*) were under cultivation in India. These exotic varieties,

introduced by the early Britishers, were adapted to cultivation under long summer days of Europe and proved unsuitable for cultivation in sub-tropical Indian plains having shorter winter days. Initial attempts to establish the potato in India were also challenged by storage during hot summers and quick degeneration of seed stocks mainly due to virus accumulation. Several attempts were made to acclimatize imported European varieties to the Indian conditions of hotter plains but these attempts proved to be a failure. It was, therefore, felt that potato cultivation in India can not depend on exotic varieties and technologies and the country must have its own research and development program for potato. As a result, a scheme for establishment of Central Potato Research Institute (CPRI) was drawn up in 1945 under the guidance of Sir Herbort Stewart, the then Agricultural Advisor to the Government of India and ICAR-CPRI was established in 1949 in Patna. Hills being the ideal location for producing and maintaining healthy seed and using potato genetic base through hybridization for breeding improved varieties, on the recommendations of an expert committee, the headquarters of ICAR-CPRI was shifted to Shimla in 1956.

During 1956 to 1983, several regional research stations were established in different potato growing zones of the country to address local problems of potato cultivation. At present the institute has seven regional stations across India. In 1971, All Indian Coordinated Research Project on Potato (AICRP-Potato) was initiated with its headquarters at ICAR-CPRI. Together, the ICAR-CPRI and AICRP account for more than 95% potato related research in the country. As a result of organized potato research on developing indigenous varieties and agro-techniques, the increase in area, production and productivity of potato during last 70 years has been almost phenomenal.

3. Promising varieties developed and released since inception of CPRI (1949).

Sr. No.	Variety	Year	Yield (t/ha)	Adaptability	Category/ Maturity	Important features
1.	Kufri Kisan	1958	15-20	-	-	-
2.	Kufri Kuber	1958	15-20	North Indian plains and plateau	Table / Early	Susceptible to late blight
3.	Kufri Kumar	1958	15-20	North Indian hills	Table/ Late	Moderately resistant to late blight
4.	Kufri Kundan	1958	15-20	North Indian hills	Table/ Medium	Moderately resistant to late blight
5.	Kufri Red	1958	20-25	Nort-eastern plains	Table/ Medium	Susceptible to labe blight
6.	Kufri Safed	1958	20-25	North Indian plains	Table/ Late	Susceptible to labe blight
7.	Kufri Neela	1963	20-25	South Indian hills	Table/ Late	Moderately resistant to late blight
8.	Kufri Sindhuri	1967	20-25	North-Indian plains	Table/ Late	Susceptible to late blight and suitable for low input area
9.	Kufri Alankar	1968	20-25	North Indian plains	Table/ Medium	Moderately resistant to late blight and early bulker
10.	Kufri Chamatkar	1968	20-25	North Indian	Table/	Susceptible to labe

				plains	Late	blight and mainly medium size tubers
11.	Kufri Chandramukhi	1968	20-25	North Indian plains and plateau	Table/ Early	Susceptible to labe blight and attarctive tubers with excellent flavour
12.	Kufri Jeevan	1968	15-20	North Indian hills	Table/ Late	Moderately resistant to late blight and early blight
13.	Kufri Jyoti	1968	25-30	Hills, Plains and plateau	Table/ Medium	Moderately resistant to late blight, wide adaptability, early bulker, slow degeneration and day neutral
14.	Kufri Khasigaro	1968	20-25	North-eastern hills	Table/ Late	Moderately resistant to late blight and early blight
15.	Kufri Naveen	1968	20-25	North-eastern hills	Table/ Late	Moderately resistant to late blight
16.	Kufri Neelamani	1968	20-25	-	-	-
17.	Kufri Sheetman	1968	20-25	Nort-western plains	Table/ Medium	Moderately resistant to late blight and frost tolerant
18.	Kufri Muthu	1971	25-30	South Indian hills	Table/ Medium	Moderately resistant to late blight
19.	Kufri Lauvkar	1972	20-25	Plateau	Table/ Early	Susceptible to late blight and heat tolerant
20.	Kufri Dewa	1973	20-25	North Indian plains	Table/ Late	Frost tolerant and good keeper
21.	Kufri Badshah	1979	30-35	North Indian plains and plateau	Table/ Medium	Resistant to late blight, early blight and PVX
22.	Kufri Bahar	1980	30-35	North Indian plains	Table/ Medium	Susceptible to late blight, moderately resistant to gemini virus and early bulker
23.	Kufri Lalima	1982	20-25	North Indian plains	Table/ Medium	Moderately resistant to late blight
24.	Kufri Sherpa	1983	15-20	North-Bengal hills and Sikkim	Table/ Medium	Resistant to late blight
25.	Kufri Swarna	1985	30-35	South Indian hills	Table/ Medium	Resistant to late blight and PCN
26.	Kufri Megha	1989	25-30	North-eastern hills	Table/ Medium	Moderately resistant to late blight
27.	Kufri Jawahar	1996	25-30	North Indian	Table/	Moderately resistant

				plains and plateau	Early	to late blight, slow degeneration, and suitable for inter-cropping
28.	Kufri Sutlej	1996	30-35	North Indian plains	Table/ Medium	Moderately resistant to late blight
29.	Kufri Ashoka	1996	25-30	North Indian plains	Table/ Early	Susceptible to late blight
30.	Kufri Pukhraj	1998	35-40	North Indian plains	Table/ Early to medium	Moderately resistant to late blight, early bulker and requires low input
31.	Kufri Chipsona-1	1998	30-35	North Indian plains	Processing/ Medium	Resistant to late blight and suitable for chips and French fries
32.	Kufri Chipsona-2	1998	30-35	North Indian plains	Processing/ Medium	Resistant to late blight, suitable for chips and French fries.
33.	Kufri Giriraj	1998	20-25	North Indian hills	Table/ Medium	Moderately resistant to late blight
34.	Kufri Anand	1999	35-40	North Indian plains	Table/ Medium	Moderately resistant to late blight, tolerant to hopper burn and frost and suitable for spring season
35.	Kufri Kanchan	1999	25-30	Nort-Bengal hills and Sikkim	Table/ Medium	Moderately resistant to late blight and slow degeneration
36.	Kufri Arun	2005	30-35	North Indian plains	Table/ Medium	Moderately resistant to late blight
37.	Kufri Pushkar	2005	30-35	North Indian plains	Table/ Medium	Resistant to late blight
38.	Kufri Shailja	2005	30-35	North Indian plains	Table/ Medium	Moderately resistant to late blight
39.	Kufri Surya	2006	25-30	North Indian plains and plateau	Processing/ Early	Susceptible to late blight, tolerant to heat and hopper burn, and suitable for early planting
40.	Kufri Chipsona-3	2006	30-35	North Indian plains	Processing/ Medium	Resistant to late blight, suitable for chips and French fries
41.	Kufri Himalini	2006	30-35	North Indian hills	Table/ Medium	Moderately resistant to late blight, good yield in both hills

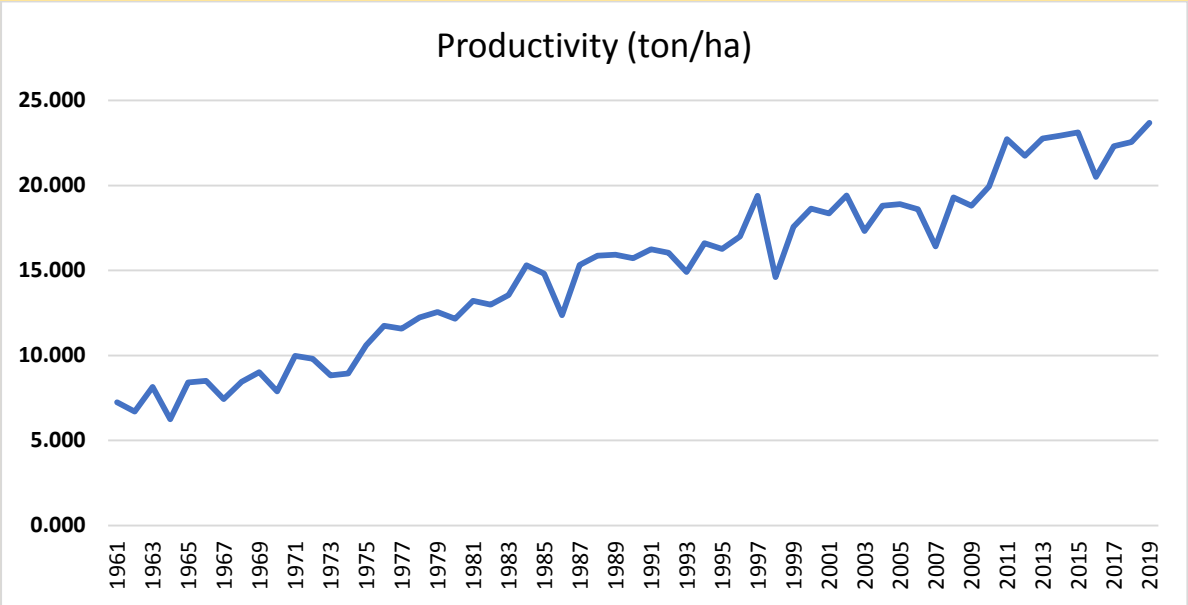
						and plains, and day–neutral
42.	Kufri Himsona	2008	15-20	Indian hills	Processing/ Late	Moderately resistant to late blight and suitable for chips
43.	Kufri Sadabahar	2008	30-35	Uttar Pradesh and adjoining area	Table/ Medium	Moderately resistant to late blight and early bulker
44.	Kufri Girdhari	2008	30-35	Indian hills	Table/ Medium	Highly resistant to late blight and long tuber dormancy
45.	Kufri Khyati	2008	25-30	North Indian plains	Table/ Early	Resistant to late blight and early blight, early bulker and suitable for high cropping intensity
46.	Kufri Frysona	2009	30-35	North Indian plains	Processing/ Medium	Resistant to late blight and suitable for French fries
47.	Kufri Neelima	2010	25-30	Nilgiri hills	Table/ Medium	Resistant to late blight and PCN
48.	Kufri Garima	2012	30-35	Indo-Gangetic plains and plateau	Table/ Medium	Resistant to late blight
49.	Kufri Gaurav	2012	30-35		Table/ Medium	Susceptible to late blight and nutrients (NPK) use efficient at sub-optimal dose
50.	Kufri Lalit	2013	30-35	Eastern plains	Table/ Medium	Resistant to late blight
51.	Kufri Mohan	2016	35-40	Northern and eastern plains	Table/ Medium	Moderately resistant to late blight
52.	Kufri Kesar	2017	25-30	North Indian plains	Table/ Medium	Moderately resistant to late blight
53.	Kufri Sukhyati	2017	25-30	North Indian plains	Table/ Medium	Moderately resistant to late blight
54.	Kufri Lima	2018	30-35 (15-20 t/ha under early heat stress)	North Indian plains	Table/ Medium to late	Susceptible to late blight, extreme resistant to PVX and PVY. Tolerant to early heat, hopper burn and mite, and suitable for early and main planting
55.	Kufri Ganga	2018	35-40	North Indian plains	Table/ Medium	Moderately resistant to late blight and tolerant to moderate drought conditions

56.	Kufri Neelkanth	2018	35-40	North Indian plains	Table/ Medium	Resistant to late blight, rich in antioxidants (anthocyanin and carotenoids), excellent flavour and speciality potatoes
57.	Kufri Manik	2019	22-25	Eastern plains	Table/ Medium	Resistant to late blight and rich in micronutrients (Fe and Zn), anthocyanin and carotenoids, and suitable for eastern plains (A bio-fortified variety)
58.	Kufri Karan	2019	22-25	Hills and plateau	Table/ Medium	High resistant to late blight, resistant to six potato viruses and potato cyst nematodes (PCN), and suitable for hills and plateau regions.
59.	Kufri Sahyadri	2019	30-35	Nilgiri hills	Table/ Medium	High resistant to potato cyst nematodes, moderately resistant to late blight, and suitable for Nilgiri hills.
60.	Kufri FryoM	2019	30-35	North west and central plains	Processing/ Medium	Resistant to late blight and PVY, and suitable for French fries.
61.	Kufri Thar-1	2019	30-35	East coast plains and middle Gangetic plains	Table/ Medium	Drought tolerant (under < 20% water stress)
62.	Kufri Thar-2	2019	35	Gangetic Plains, Trans-Ganga Plains, Central Plateau and Hills and Western Dry Region	Table/ Medium	Drought tolerant (under < 20% water stress)
63.	Kufri Thar-3	2019	45	Transgangetic plains, Upper gangetic	Table/ medium	Drought tolerant, performed well in Hisar, Modipuram &

				plains and Eastern plateau & hills		Raipur locations.
64.	Kufri Sangam	2019	35-40	Gujarat plains and Hills, Central Plateau and Hills and Eastern plateau and Hills for processing; & Northern plains for table purpose	Processing & Table/ Medium	Moderately resistant to late blight and excellent storability. Suitable for both processing & Table purpose.
65.	Kufri Chipsona-4	2019	30-35	Southern plateau and hills, Lower Gangetic plains, Central plateau and hills and Gujarat plains and hillls.	Processing/ Medium	Moderately resistant to late blight. This is an old institute released potato variety (in 2010) and is already in seed chain.

4. Incremental gains in key characteristics (Use figures, graphs to show the following indicators. Give this variety wise)

Impact of overall production technologies on national average yield



5. Seed production and distribution

Share of ICAR-CPRI varieties

Year	Breeder Seed Supply (tonnes)	Top three varieties (% share)
2016-17	2238.55	Kufri Bahar (29.16%) Kufri Jyoti (13.37%) Kufri Pukhraj (10.62%)
2017-18	2089.35	Kufri Bahar (24.61%) Kufri Jyoti (12.85%) Kufri Khyati (10.66%)
2018-19	2308.05	Kufri Bahar (24.46%) Kufri Jyoti (12.78%) Kufri Khyati (11.24%)

Top supplied varieties during the last three years by ICAR-CPRI

Variety	2018-19	%share	2017-18	% share	2016-17	% share
Kufri Bahar	564.75	24.46	514.39	24.61	652.85	29.16
Kufri Jyoti	295.03	12.78	268.52	12.85	299.47	13.37
Kufri Khyati	259.64	11.24	222.8	10.66	227.6	10.16
Kufri Chipsona-1	179.32	7.769	148.58	7.11	111.87	4.99
Kufri Pukhraj	155.75	6.74	186.81	8.94	237.81	10.62
Kufri Sindhuri	147.99	6.41	146.79	7.02	163.41	7.29
Kufri Chipsona-3	120.41	5.21	86.44	4.13	100.49	4.48
Kufri Chandramukhi	102.81	4.45	62.37	2.98	52.57	2.34
Kufri Surya	91.71	3.97	125.32	5.99	60.67	2.71
Kufri Mohan	84.53	3.66	NA	NA	NA	NA
Total	2308.08	100	2089.33	100	2238.55	100

6. Estimates on adoption of few promising varieties

Top potato varieties in terms of area coverage in India

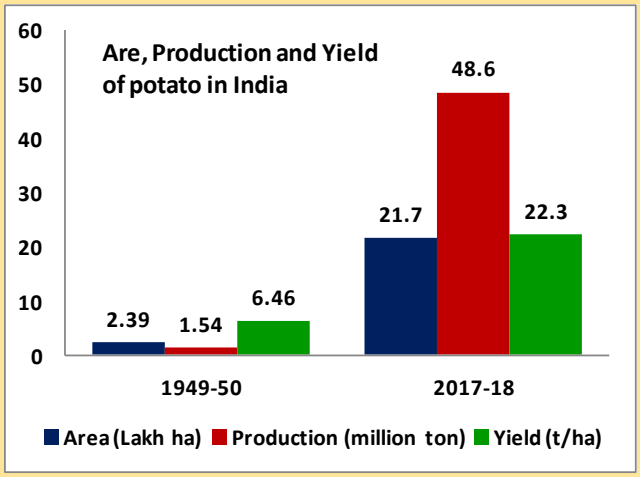
S.N.	Variety	Area occupied (%)
1.	Kufri Pukhraj	33.04
2.	Kufri Jyoti	20.67
3.	Kufri Bahar	17.28
4.	Kufri Chipsona-1	3.86
5.	Kufri Khyati	2.02
6.	Kufri Chandramukhi	2.00
7.	Kufri Sindhuri	1.97
8.	Kufri Chipsona-3	1.57
	Total	**82.41**

Indian potato varieties/ hybrids commercially grown in other countries

Country	Varieties/Hybrids
Afghanistan	Kufri Chandramukhi
Nepal	Kufri Jyoti, Kufri Sindhuri
Bhutan	Kufri Jyoti
Bangladesh	Kufri Sindhuri
Mexico	I-654 as CCM-69.1
Sri Lanka	I-822 as cv. Khrushi, I-1085 as cv. Sita
Philippines	I-1035 as cv. Montanosa, I-1085 as cv. BSUP-04
Madagascar	I-1035 as Malaika
Bolivia	I-1039 as cv. India
Vietnam	I-1039 as cv. Red skin

7. Impact indicators of few promising varieties

7.1 Impact on potato production



Technologies developed by CPRI and their large scale adoption by all the stakeholders (farmers, cold store owners, processing industry, seed industry, farm machinery sector, etc.) has resulted in 9.07 times increase in area, 31.55 times increase in production, and 3.45 times increase in yield during 1949-50 to 2017-18. India is the second largest potato producer contributing nearly 8% of global production (388.19 million tonnes) during 2017-18. Indigenous varieties developed by the institute played an important role in this remarkable achievement.

7.2 Impact of table potato varieties

- India produced 45.87 million tonnes of potato annually during the triennium 2014-17 and contributed Rs. 57,512 crore annually to the Gross Value Added (GVA) at current price.
- Potato varieties developed by ICAR-CPRI are very popular among farmers and cover nearly 95% of total area under potato cultivation. These varieties contributed about Rs. 54,636 crore annually during 2014-17.
- Four ICAR-CPRI varieties namely Kufri Jyoti, Kufri Bahar, Kufri Pukhraj and Kufri Chipsona-1 together contributed about more than 75% of total area under potato in India.
- Presently, Kufri Jyoti, bred in 1968, occupies about 21% are in the country and contributes about Rs. 11,800/- crore to the agriculture economy.
- Similarly, Kufri Bahar- released in 1980- became the principal potato variety of Uttar Pradesh, the highest potato producing state in the country. It occupies about 17% area and contributes about Rs. 9,9551/- crore to the agriculture economy.

- An early bulking variety (60 days), Kufri Pukhraj-released in 1998- is the leading variety today in India occupying about 33% area. It contributes nearly Rs. 18,541 crore to the agriculture economy. It is the most suitable variety for rice-wheat based cropping sequence in the northern plains.

7.3 Impact on processing potato varieties

Kufri Chipsona-1 released in 1998 is the first potato variety suitable for processing and 4th leading variety of the country today occupying about 4% area under potato and contributing about Rs. 2,247 crore to the agriculture economy. Besides, five more varieties have been released by the institute catering to almost 35% of raw material for the processing industries. Potato processing companies like M/s Frito Lay India (Pepsico), ITC Ltd., Merino Industries, Mc Cains India, PRAN Food Ltd., Haldiram, Pailan Food Ltd., Balaji Wafers, Golden Fries, Bikaji Foods International Ltd. etc. use Indian processing varieties and sell their products as >100 brand names. This has resulted in tremendous growth in processing sector from mere <1% during 1990s to > 8% now.

7.4 Impact of seed production technology

Seed Plot Technique was developed in 1960's by the institute to enable disease free seed potato production in sub-tropical plains to meet the country demand. Now ICAR-CPRI produces nearly 3000 metric tonnes of Breeder seed of potato annually. These seeds are supplied to the state departments to produce about 6,48,000 metric tonnes of Certified seed, which is about 10% of the total seed requirement based on 100% seed replacement rate; and about 30% on 33% replacement rate as followed by the growers. With the average prevailing price of seed potato, country saves about Rs. 2,000/- crore annually on import of seed potato.

7.5 Impact of aeroponics technology (Hi-tech seed production)

Traditional seed production system has the limitation of repeated exposure of initial disease free seed stocks to soil and insect pests which resulted in accumulation of pathogens. Therefore, ICAR-CPRI developed an aeroponic technology of hi-tech seed production. It shortens the span of quality seed production by 2 years. The aeroponic technology has revolutionized potato seed industry in the country. The institute has generated nearly 2 crore as licensing fee by commercialization of this technology to several private firms. Each firm was licensed to produce one million minitubers by aeroponic technology. Even at half of their capacity, about 6.50 million minitubers are being produced through this technology. After four successive multiplications, it shall make available 70,400 tonnes of seed potatoes in addition to the conventional system.