Potato J (2022) 49 (2): 141-148

RETURNS TO POTATO RESEARCH IN INDIA: A CASE OF KUFRI PUKHRAJ

N K Pandey[1]*, P Kharumnuid[1], Sant Kumar[2]*, S K Chakrabarti[3] and Vinay Bhardwaj[1]

ABSTRACT: This study has estimated returns accrued from a potato variety called Kufri Pukhraj developed by ICAR-CPRI in 1998. This variety is most popular in North Indian Plains and covers about 33 % of total potato area in India. Time-series data collated from published records have been used to assess benefits during the period 1978-2021. The economic surplus model is employed to measure benefits in a closed economy framework at all-India level. Results have shown that adoption of Kufri Pukhraj provided gross returns of Rs 1,03,585 crore during the period 1978-2021, and large benefits have gone to consumers (73 %) and remaining to producers. The average annual return was assessed as Rs 2,354 crore. The NPV from spending in potato research was observed Rs 20,073 crore, and Rs 7,975 crore at 5 % and 8 %, respectively, during the study period. The IRR from monetary benefits was 49 %, a good rate of returns. Sensitivity analyses have provided substantial returns, and IRR between 46-51 %. The study infers that spending on R&D on potato has proved financially beneficial and suggests that other major technologies (varieties/ production practices/ others) having special traits may be studied for justifying past funding and make the strong case for future funding.

KEYWORDS: Potato, Kufri Pukhraj, Economic Surplus, IRR, NPV

INTRODUCTION

The role of agricultural research in transforming India's food security situation brining the country attaining top position among countries of the globe in production of few commodities is well known. Realizing the role of agricultural research in improving yield and increasing production, the governments and other agencies have given substantial funding for building research and development (R&D) infrastructure in past decades. However, the lack of funding for any economic activities like R&D is a global issue including India. The governments and other agencies are now interested in evidences of past achievements on people and regions to make the basis for funding future projects. Because, investment in agricultural research has helped in improving the welfare of farmers and consumers by reducing costs and providing food at cheaper rate, increasing production and product quality, or introducing new products (Araji *et al.* 1995). Studies assessing the impacts of investment in agricultural research have reported high social payoffs (Joshi *et al.,* 2015; Chand *et al*., 2012; Ruttan 1982; Arndt *et al.,* 1977; Akino and Hayami 1975; Evenson and Jha 1973). Most of these studies were confined to estimation of aggregate benefits from agricultural research. Measuring research benefits at an aggregate level has limitations in terms of relevance to decision making at the micro-level. Evenson (1967) argued that a more useful approach is to measure research productivity for a particular commodity or a particular agricultural experiment station.

The past studies have assessed the impact of research for a wide range of commodities (Punia *et al*. 2017). Although, the aspects like climate change on potato yield is studied (Pradel *et al*. 2019; Dua *et al.* 2013), the monetary benefits from a potato variety/ technology is less studied in India.

[12]ICAR-Central Potato Research Institute, Shimla - 171 001, Himachal Pradesh, India
[2]ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi-110012
[3]Uttar Banga Krishi Vishwavidyalaya (UBKV), Cooch Behar (West Bengal) -736 165
*Corresponding authors; email: nkpcpri@gmail.com, sant.kumar@icar.gov.in

Dahiya (2005) in a study tried to justify the impact of potato research, by comparing both area and value of production (VOP) with rice and wheat. Study noted that potato has performed better than rice and wheat. Potato is grown on 1 % of gross cropped area (GCA) and contributes about 3 % of the VOP from agriculture (crop), i.e. thrice the area under cultivation. As against this, rice occupied 22 % of GCA but contributed only 14 % to the VOP from agriculture. The corresponding figures for wheat were 15 % and 9.6 % during triennium ending (TE) 2018-19.

The VOP from potato was Rs. 29,310 crore (at 2011-12 prices) during TE 2018-19 (MoSPI 2021). Moreover, funding agencies are now skeptical of spending to various sectors/ programs/ commodities having alternatives uses. Presently, funding agencies are more interested in investing resources for targeted people and areas for better results. Keeping in view, the present study attempts to assess the monetary benefits of popular potato variety Kufri Pukhraj at all-India. *Firstly*, paper provides profile of potato production and about variety. *Secondly*, it describes data, methodology and framework adopted for analysis. *Finally*, monetary benefits from Kufri Pukhraj under various scenarios have been discussed.

PROGRESS OF POTATO IN INDIA

Production Profile

Potato is an important food crop in India. It is grown in almost all states under diverse agro-climatic conditions, except coastal areas. This crop is grown during short-winter days from October to February/ March. Therefore, availability of sunshine is the main factor for deciding yield of potato in India (Kumar *et al.* 2015). During TE 2020-21, India produced about 53 million tonne (Mt) of potato from 2.1 million hectare (Mha) area with a yield level of 24 t/ ha (Fig. 1). However, substantial area under potato lies in eight major states of India viz., Uttar Pradesh, West Bengal, Bihar, Gujarat, Madhya Pradesh, Punjab, Karnataka and Assam. These states together accounted for about 87 % of area and 92 % of production in the country during TE 2020-21 (Table 1).

State-wise performance of potato has shown that, Uttar Pradesh accounted for about 30% of total production in India, followed by West Bengal (24%), and Bihar (16%) in 2020-21. The yield level in Gujarat and West Bengal (about 30 t/ha, each) was highest among the major states of India. It was 6 t/ha higher than the national average

Table 1. Share of area and production and yield of potato in major states, TE 2020-21

State	Per cent share		Average yield (t/ha)
	Area	Production	
Assam	4.7	1.4	7.3
Bihar	14.7	16.5	27.2
Gujarat	5.9	7.3	29.9
Karnataka	1.5	1.0	15.7
Madhya Pradesh	6.9	6.3	22.8
Punjab	4.8	5.3	26.4
Uttar Pradesh	28.4	30.2	25.8
West Bengal	20.1	24.3	29.3
Other states	12.9	7.4	14.1
All-India	100.0	100.0	24.2

Source: NHB (2021)

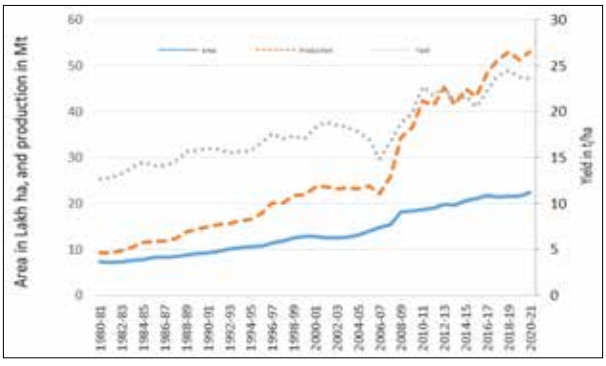

Fig. 1. Trends in area, production and yield of potato in India

(24.2 t/ha). By increasing the yield of potato in major states to the level of Gujarat and West Bengal, about 8 Mt additional potato can be added to total production. Apart from bio-physical factors like fluctuation in temperature; assured irrigation, timely and adequate availability of inputs, especially of seeds and fertilizers, and low seed replacement rate are the main factors responsible for poor yield in major states. Adopting micro-irrigation in place of furrow method and good agricultural practices can make this attainable (Kumar *et al*. 2009, Kumari 2012; Singh 2013).

Varietal Progress in India

Till date, more than 80 varieties of potatoes have been introduced for production in India, wherein 66 varieties (82%) have been developed by ICAR-Central Potato Research Institute (CPRI), Shimla. This public funded Institute is responsible for coordinating, managing, and guiding the potato sector in India. The potato varieties developed by CPRI are classified into early, medium and late categories based on maturity period[1] (Kumar *et al.* 2014). In depth scrutiny has revealed that majority of varieties of CPRI are of medium maturity (73%), followed by long maturity (15%) and remaining are early maturity (12%). Since, potato is used mainly as vegetable throughout year in India, early to medium maturity varieties offering better yield, tolerant to multi-stresses and better storability are preferred over others in the development process. Need of desired variety seeds and their availability are key parameters of adoption of varieties.

Among the potato varieties, Kufri Pukhraj is most popular in India in terms of area coverage. This variety covered about 521.38 thousand hectares (i.e. 33% of potato area) in 2015 and grown in Bihar, Gujarat and Punjab, Uttar Pradesh and West Bengal. It is preferred by the farmers due to early-maturity and high-yielding. The second most dominant variety in India is Kufri Jyoti (1968) covered an area of 325.67 thousand hectares (21% of potato area). It is most dominating variety in Karnataka and West Bengal. Despite prone to late blight and lower yield over to Kufri Pukhraj, this variety is still preferred by farmers due to good shape and storability, tuber size, and a slow degeneration rate. The third most popular potato variety is Kufri Bahar (1980) covered 272.64 thousand hectares (17% of potato area) in Uttar Pradesh. Besides, some notable varieties being used for industrial purposes include Kufri Chipsona 1, Kufri Chipsona 3, including foreign varieties namely Atlantic, Kennebec and Lady Rosetta. Released in 1998, Kufri Chipsona 1 is cultivated mainly in Uttar Pradesh for industrial use. It has low sugar content, high dry matter, and good tuber size and shape.

Kufri Pukhraj

Released by ICAR-CPRI in 1998, Kufri Pukhraj is an early maturing and most popular among the potato varieties and gives yield between 35-40 t/ha. It has medium storability and resistance to early blight and moderate resistance to late blight. This variety is not suited to early sowing due to heat sensitive and limited yield (Rana *et al*. 2013). It has a waxy texture, mild flavor, and free from discoloration after-cooking and coloration on exposure to light. This variety is grown mainly in North Indian plains and Plateau regions wherein above 80% of total potato area lies. Tubers of Kufri Pukhraj are an excellent source of vitamin C, potassium, and fibre. As this variety is the most popular among all varieties, evidence on monetary benefits from investment in research seems

1Note: varieties mature between 70-90 days are classified as early, varieties mature between 100-110 days are classified as medium, and varieties require more than 110 days to mature, are classified as late.

pertinent for researchers, policymakers, government and other stakeholders.

MATERIALS AND METHODS

Data

The present study has used secondary data collated from published records and other sources. Data on production and prices of potato was obtained from Indian Horticulture Database, while demand and supply elasticities are taken from published record (CPRI 2009). The maximum adoption level for Kufri Pukhraj has taken from Pradel *et al*. (2019), and data on yield gain, reduction in cost, lag to first adoption (years) are collected from frontline demonstrations and published sources (Kang *et al.,* 2000). The data on research cost was built in from records of ICAR-CPRI and covered items like scientists' salary (including personnel from All India Coordinated Research Project), operational expenses, overhead cost and cost of extension. The benefits accrued from the variety was assessed for the period 1978-2021. The discounted stream of benefits and costs have been arrived at using World Bank Gross Domestic Product (GDP) deflator for India[2]. The summary data used for assessing economic surplus are provided in Table 2.

Theoretical Framework and Concept of Economic Surplus Model

This study has applied economic surplus model (ESM) in *ex-post* framework to estimate the potential monetary returns to research and extension investment on Kufri Pukhraj in India. The model assumes that with the adoption of Kufri Pukhraj, the supply curve will shift downward from S_0 to S_1, and the domestic demand curve of potato, and demand curve D is to remain unchanged (Fig. 2).

As a result of shift in supply curve, consumer will be benefited from reduction in price (P_0 to P_1) as consumer surplus changes, equal to the area P_0abP_1, and the change in producer surplus is equal to the area $P_1bI_1 - P_0aI_0$. The area beneath the demand curve and between the two supply curves i.e., area I_0abI_1 represents the total surplus from the research induced supply shift (Alston *et al.* 1995).

The analysis has been done in closed economy framework, since the export of potato and its products from India is very limited. A total period of 44-years (1978-2021) have been considered for developing the streams of costs and benefits. The research for breeding Kufri Pukhraj was initiated in 1978 and the variety was released after 20 years in 1998 (Kang *et al.,* 2000) Following Alston *et al.* (1995), the changes in producer, consumer, and total surplus in the closed economy are estimated using following formula:

$$\delta CS_t = P_0Q_0\, Z_t\, (1 + 0.5Z_t\eta) \quad (1)$$

$$\delta PS_t = P_0Q_0\, (Kt - Zt)\, (1 + 0.5Zt\eta) \quad (2)$$

$$\delta TS_t = \delta CS + \delta PS = P_0Q_0\, Kt\, (1 + 0.5Z_t\eta) \quad (3)$$

$$Z_t = K_t\, \varepsilon\, /\, (\varepsilon + \eta) \quad (4)$$

where, $\Delta\, CS_t$ is the change in consumer surplus in year t, $\Delta\, PS_t$ is the change in

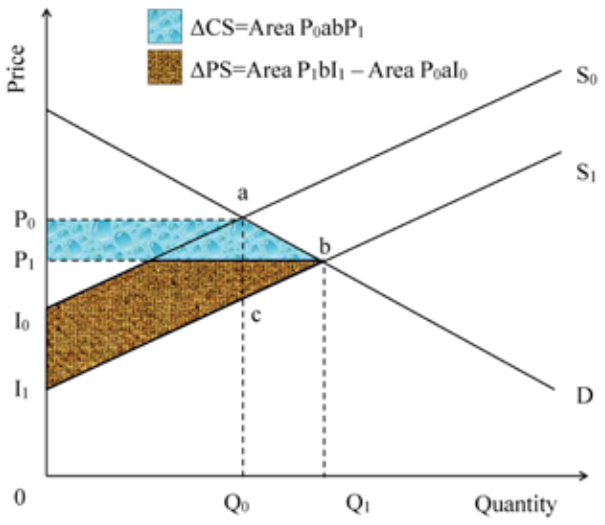

Fig. 2: Changes in economic surplus (closed economy) from the adoption of Kufri Pukhraj

[2]World GDP Deflator for India at 2019-20 prices has been used for deflating stream of costs and benefits. https://data.worldbank.org/ indicator/NY.GDP.DEFL.ZS?end

Table 2. Parameters and assumptions used for analysis of returns from Kufri Pukhraj

Base Parameter	Value	Source
Average price level for TE 2019-20	Rs 13.6/ kg	Monthly Potato Report, MoAFW, GoI 2020
Production quantity (1999-00 to 2020-21)	Thousand tonnes	Indian Horticulture Database various years
Supply elasticity (ε)	0.8	CPRI Annual Report (2008-09)
Demand elasticity (η)	0.3	CPRI Annual Report (2008-09)
Proportionate yield gain [E(Y)]	15 %	Scientists' opinions, field survey, FLD data
Proportionate reduction in cost [E(C)]	15 %	Scientists' opinions, field survey, FLD data
Maximum adoption level	33 %	Pradel *et al.* (2019), CPRI reports
Lag to first adoption (years)	20 year (1978-98)	Kang *et al.,* (2000), review of literature
Year to full adoption	11 years	Scientists' opinions
Depreciation	5%	Scientists' opinions
Research Period	1978-1998	Kang *et al.,* (2000), review of literature

producer surplus in year t, ΔTS_t is the change in total surplus, P_0 is the initial price, Q_0 is the initial level of production, Z_t is the reduction in price as a result of an increase in supply due to adoption of Kufri Pukhraj, η is absolute value of demand elasticity, ε is the supply elasticity and K_t is the proportionate supply shift in the year t due to adoption of the variety. The value of K_t can be obtained as:

$$K_t = \{[E(Y)] / \varepsilon - [E(C)] / [1 + E(Y)]\} pA_t (1-\delta_t) \quad (5)$$

where, E(Y) is the proportionate change in yield per ha, E(C) is the proportionate change in variable input costs per ha, p is the success rate, A_t is the adoption rate in year t and δ_t is the rate of annual depreciation in year t. Once change in economic surplus is projected over time, the net present value at the rates of 5 and 8 per cent, and internal rates of return are calculated along with sensitivity analyses. The estimates of returns and costs were deflated in real terms using a World Bank GDP deflator for India at 2019-20 price level.

RESULTS AND DISCUSSION

Adoption of Kufri Pukhraj at farmers' fields with 33% adoption level accrued gross returns / surplus of Rs 1,03,585 crore (at 2019-20 prices) to the country's economy during 1978-2021, with average annual return of Rs 2,354 crore (Table 3). Of gross returns, large share of 73 % (Rs 75,335 crore) have gone to consumers, and remaining 27 % (Rs 28,250 crore) to potato producers. The NPV of research spending is estimated as Rs 20,073 crore and Rs 7,975 crore at discount rates of 5% and 8%, respectively. The IRR from research investment is estimated as 49%, which is a good rate of returns. Past studies have also reported similar rates of returns from investment in agricultural research (Rada and Schimmelpfenning 2018; Punia *et al.* 2017; Chand *et al.* 2012). Due to the uncertainties in parameters used for estimating gains, the

Table 3. Returns to investment in research in Kufri Pukhraj, 1978-2021

(Amount Rs crore)

Particulars	Returns to research
Consumer surplus	75, 334.8
Producer surplus	28, 250.5
Total surplus	1, 03, 585.3
Annual average gross return	2,354
NPV at 5% discount rate	20, 072.7
NPV at 8% discount rate	7, 975.0
Annual net benefit	2, 143.4
IRR (%)	49

Source: Authors' estimate

sensitivity analyses have also been made. The various levels of adoption, yield gains, change in cost and others details are provided in Appendix Table 1. Sensitivity analysis shows that gross returns ranges from Rs 57,051 crore to Rs 1,54,318 crore, and IRR between 46-51%.

The results of base model and sensitivity analyses have shown that spending in development of Kufri Pukhraj has benefitted immensely to the society and Indian economy. Growing of early variety, which mature between 70 and 90 days, provide more flexibility in harvesting of crop and potentially provides additional income if cultivated in between two rice cycles (Bardhan *et al*., 2007). This variety is preferred by farmers because of its short-maturity, drought tolerant, low inputs need, suitable for many potato-based cropping systems and can be harvested early for getting premium price. It benefits producers because of early-maturity and produces sizeable yields, even if harvested pre-maturely after 60 days.

Studies have noted that suitable growing window of potato gradually been shortened in the Indo-Gangetic Plains due to rise in temperature and event of drought have become frequent, resulting negative impact on yield (Kang *et al.,* 2000). These pose enormous challenge to scientists, extension agents and farmers, who are targeting to achieve average yield of about 35 t/ha in India by 2050 to meet the future demand of growing population. In order to cope up with these challenges, the ICAR-CPRI need to put emphasis on development of varieties which are early maturing, and resistant to drought and heat (Kumar *et al.*, 2015). Although, the Potato Institute has developed cultivars like Kufri Khyati and Kufri Mohan on the lines of Kufri Pukhraj which perform very well in the farmers' fields and offering better yield than Kufri Pukhraj. However, these varieties are less popular among farmers. There could be several reasons for this like poor information about these varieties, high seed cost, and non-availability of quality seeds at sowing time. The farmers should be made aware of these varieties by organizing extension activities like training, frontline demonstrations, and advisory services. The private sectors should also be encouraged to take up production of quality seeds of

Appendix Table 1. Sensitivity analysis for gross returns and net present value from adoption of Kufri Pukhraj, 1978-2021

(Rs Crore)

Particulars	Net present value		IRR (%)	Gross returns			
	5%	8%		Consumer surplus	Producer surplus	Total surplus	Annual average
Base level scenario							
(i)Adoption level (33%) (ii) Yield increase (15%) (iii) Cost reduction (15%)	20,072.7	7,975.0	49	75,334.7	28,250.5	1,03,580.3	2,354.2
Moderate scenario							
(i)Adoption level (25%) (ii) Yield increase (10%) (iii) Cost reduction (10%)	11,286.3	4,539.9	46	41,491.3	15,559.3	57,050.6	1,296.6
Optimistic scenario							
(i)Adoption level (40%) (ii) Yield increase (20%) (iii) Cost reduction (20%)	29,407.0	11,570.0	51	1,12,231.0	42,086.6	1,54,317.7	3,507.2

Source: Authors' estimate

improved varieties and supply to farmers at reasonable prices. Other adaptation strategies like micro-irrigation using drip and fertigation should be popularized to reduce production cost and sustained increase in yield.

CONCLUSION AND IMPLICATIONS

Systematic analysis of improved production technology including varieties are key to provide concrete evidence on returns to past funding and generate more funding for R&D in future. The analysis has shown that Kufri Pukhraj is the most popular among all the cultivars and covers about 33 % of total potato area at all-India. This variety is widely grown in states of Bihar, Gujarat and Punjab, including Uttar Pradesh and West Bengal. The gross returns/economic surplus from Kufri Pukhraj is estimated as Rs 1,03,585 crore (at 2019-20 prices) for the period 1978-2021. The IRR from investment was 49 %. The sensitivity analyses have shown that the variety have potential to give substantial returns between Rs 57,051 to Rs 1,54,318 crore and IRR ranging 46-51 % at varying level of adoption. Study noted that addressing supply side constraints and irrigation practices, significant increase in potato yield and production can be achieved. The results of analysis infer that other major technologies (consisting varieties, production practices and others) having special traits may be targeted for development process to address the negative impacts of emerging climate change and other problems. Also, the location specific improved varieties need to be popularized among farmers through effective and efficient extension activities for harnessing the potential. Efforts should be also made to promote micro-irrigation technologies among the potato farmers to avoid depletion of groundwater and hardness of soil, which otherwise limit yield. Quality seed production programme should be taken up on a large scale by the stakeholders so that farmers can get quality seeds of desired varieties at cheaper price rate and at right time. Regular seed replacement plays a major role in increasing yield. A study by Kant *et al.* (2020) in Bihar showed 53.28 % increase in yield when farmers replaced local existing varieties with improved seeds of Kufri Pukhraj.

ACKNOWLEDGEMENT

The authors are grateful to ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi, for providing support to write this paper.

CONFLICT OF INTEREST

The authors confirm that this manuscript has no conflict of interest

LITERATURE CITED

Akino M and Hayami Y (1975) Social returns to Agricultural Research Investment. *American Journal of Agricultural Economics* 57:1-10.

Alston JM, Norton GW and Pardey PG (1995) Science Under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting. *Cornell University Press*, Ithaca.

Araji AA, White FC, Guenther JF (1995) Spillovers and the Returns to Agricultural Research for Potatoes. *Journal of Agriculture and Resource Economics 20* :263-276.

Arndt TM, Dalrymple DG and Ruttan VW (1977) Resource Allocation and Productivity in National and International Agricultural Research. Minneapolis: University of Minnesota Press.

Bardhan Roy SK, Saha NK, Kadian MS, Quiroz R, Ilangantileke S (2007) Improving the Livelihood of Farmers by Intensifying the Rice-potato-rice System through Double-transplanting of Rice in West Bengal, India. Natural Resources Management Division Working Paper No. 2007-1.

Chand R, Kumar P and Kumar S (2012) Total Factor Productivity and Returns to Public Investment on Agricultural Research in India. *Agricultural Economics Research Review*, 25 (2): 181-194.

CPRI (2009) *Annual Report 2008-09*. ICAR-Central Potato Research Institute, Shimla (India), p.137.

Dahiya PS (2005) Socioeconomic Impact of Investments in Potato Research and Development in India. In: *Impact of Agricultural Research: Post-Green Revolution Evidence in India*, Joshi, P K, Suresh Pal, P.S. Birthal and MCS Bantilan, ed.), ICAR- National Institute of Agricultural Economics and Policy Research, New Delhi, India.

Dua VK, Singh BP, Govindakrishnan PM, Kumar SS Lal (2013) Impact of Climate Change on Potato Productivity in Punjab- A Simulation Study. *Current Science* 105: 787-794.

Evenson RE (1967) The Contribution of Agricultural Research to Production. *Journal of Farm Economics* 49: 1415-1425.

Evenson RE, Jha D (1973) The Contribution of Agricultural Research System to Agricultural Production in India. *Indian Journal of Agricultural Economics*, 38:212-230.

GoI (2020) Monthly Potato Report 2020. *Horticulture Statistics Division*. Ministry of Agriculture and Farmers Welfare, Government of India.

Joshi PK, Kumar P and Shinoj P (2015) Public Investment in Agricultural Research and Extension in India. *European Journal of Development Research*, 27 (3):438-451.

Kang, GS, Rana MS, Gopal J, Gaur PC and Pandey SK (2000) Kufri Pukhraj-An Early Bulking Main Crop Potato variety for Plains and Plateau of India. *Journal of Indian Potato Association*, 27(3&4):77-82.

Kant K Ghanshyam, Gupta SK, Patel AB, Kumar S, Kumar A, Vishwakarma R, Sohane RK (2020) Influence of Varietal Replacement Demonstration on Yield and Economics of Potato (*Solanum tubrososum*) cv. Kufri Pukhraj in Bhagalpur District of Bihar. *Journal of Pharmacognosy and Phytochemistry* 9: 1758-1761.

Kumar S, Asrey R, Mandal G, Singh R (2009) Micro-Sprinkler, Drip and Furrow Irrigation for Potato (*Solanum tuberosum*) Cultivation in a Semi-Arid Environment. *Indian Journal of Agricultural Sciences* 79 (3): 165–169.

Kumar SN, Govindakrishnan PM, Swarooparani DN, Nitin Ch., Surabhi, J, Aggarwal, PK (2015) Assessment of impact of climate change on potato and potential adaptation gains in the Indo-Gangetic Plains of India. Int. J. Plant Prod. 9 (1), 151–170.

Kumar V, Luthra SK, Bhardwaj V and Singh BP (2014) Indian Potato Varieties and Their Salient Features. *Technical Bulletin No. 78* (revised). ICAR-Central Potato Research Institute, Shimla, Himachal Pradesh.

Kumari S (2012) Influence of Drip Irrigation and Mulch on Leaf Area Maximization, Water Use Efficiency and Yield of Potato (*Solanum tuberosum* L.). *Journal of Agricultural Science* 4 (1): 71- 80.

MoSPI (2021) State-wise and item-wise value of output from agriculture, forestry and fishing: 2011-12 to 2018-19, Ministry of Statistics and Programme Implementation, Government of India.

NHB (2021) Indian Horticulture Database. National Horticulture Board, Ministry of Agriculture and Farmers Welfare, Government of India.

Pradel W, Gatto M, Hareau G, Pandey SK and Bhardwaj V (2019) Adoption of potato varieties and their role for climate change adaptation in India, *Climate Risk Management*, 23: 114-123.

Punia S, Anbukkani P and Pal S (2017) Recent Productivity Trends and Impact of Technology in the Rice-Wheat System of the Indi-Gangetic Plains. In: *Agricultural R&D Policy in India* (Suresh Pal, ed.). National Institute of Agricultural Economics and Policy Research, New Delhi.

Rada Nicholas, David Schimmelpfenning (2018) Evaluating Research and Education Performance in Indian Agricultural Development, *Agricultural Economics* 49:395-406.

Rana RK, Sharma N, Arya S, Singh BP, Kadian MS, Chaturvedi R and Pandey SK (2013) Tackling Moisture Stress with Drought-tolerant Potato (*Solanum tuberosum*) Varieties: Perception of Karnataka farmers. *Indian Journal of Agricultural Sciences*, 83 (2): 216–222.

Ruttan V.W. (1982) Agricultural Research Policy. Minnesota, USA; *University of Minnesota Press*. 370.

Singh JP and Lal SS (2009) Climate Change and Potato Production in India. In: ISPRS Archives XXXVIII-8/ W3 *Workshop Proceedings*: Impact of Climate Change on Agriculture 115–117.

Singh OP (2013) Hydrological and Farming System Impacts of Agricultural Water Management Interventions in North Gujarat, *Indian Journal of Agricultural Economics* 68 (3): 292-312.

MS Received: August 23, 2022; Accepted: December 22, 2022