Vegetable Science (2026) 53(1): 190-194

doi: 10.61180/vegsci.2026.v53.i1.25

ISSN- 0970-6585 (Print), ISSN- 2455-7552 (Online)

www.isvsvegsci.in

RESEARCH ARTICLE

Economic impact assessment and technology adoption of okra variety Kashi Kranti

S.K. Sanwal[1,2*], Suresh Kumar[2], Pardeep Karmakar[1], Govind Pal[1], Rajesh Kumar[1] and B. Singh[1]

Abstract

Okra variety 'Kashi Kranti', developed by Indian Institute of Vegetable Research, Varanasi, is an early-maturing, medium-tall variety (100–115 cm) with dark green fruits (8–10 cm long), high yield potential (140–150 q/ha), and resistance to yellow vein mosaic virus (YVMV) and okra enation leaf curl virus (OELCV). Using an ex-post and ex-ante assessment framework based on the economic surplus approach (Alston et al. 1995), the study quantified the benefits of its adoption. Adoption rates were estimated using breeder seed data and an S-shaped logistic function, reaching approximately 3.71% by 2024 and projected to approach 4.95% by 2030. Two yield gain scenarios (15 and 25% over prevailing varieties) were analyzed based on multi-year field data. Results showed substantial welfare gains. Under Scenario-I (15% yield gain), total economic surplus from 2012–2024 was ₹373.45 crore (annualized ₹28.73 crore), rising to ₹596.39 crore by 2030. Under Scenario-II (25% yield gain), the surplus reached ₹624.00 crore (2012–2024) and ₹997.08 crore by 2030. Producer surplus constituted the major share, reflecting higher productivity and profitability for farmers. The findings highlight Kashi Kranti's significant contribution to yield enhancement, cost efficiency, and overall economic returns for producers, consumers, and society. Accelerated adoption of such improved varieties can strengthen vegetable production sustainability and support smallholder livelihoods in India.

Keywords: Okra, Kashi Kranti, economic impact assessment, technology adoption

[1]ICAR-Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh, India

[2]ICAR- Central Soil Salinity Research Institute, Karnal- 132001, Haryana, India

***Corresponding author;** Email: sksanwal2016@gmail.com

Citation: Sanwal, S.K., Kumar, S., Karmakar, P., Pal, G., Kumar, R., & Singh, B. (2026). Economic impact assessment and technology adoption of okra variety Kashi Kranti. Vegetable Science, 53(1), 190-194.

Source of support: Nil

Conflict of interest: None.

Received: 30/01/2026; **Revised:** 25/05/2026; **Accepted:** 28/05/2026

Introduction

Vegetable crops are a cornerstone of India's agriculture, nutrition, and economy. They provide essential micronutrients such as vitamins A, C, and K, minerals like iron and potassium, dietary fiber, and antioxidants that are critical for human health. Regular consumption of vegetables helps prevent malnutrition, reduces the risk of chronic diseases including diabetes, cardiovascular issues, and certain cancers, and supports overall dietary diversity (Dudi & Sanwal, 2004). In a country like India, where diets often rely heavily on cereals, vegetables play a vital role in addressing hidden hunger and improving public health outcomes (Sanwal et al, 2012). India ranks as the second-largest producer of vegetables globally, after China. As per the final estimates for 2024-25 released by the Department of Agriculture & Farmers Welfare, vegetable production reached 217.797 million tonnes, marking a 5.11% increase over the previous year. Economically, vegetable crops are high-value, short-duration commodities that offer higher returns per unit area compared to many field crops. Their cultivation generates significant employment, particularly for small and marginal farmers and rural women, as they require intensive labor for sowing, weeding, harvesting, and post-harvest handling.

Okra (also known as bhindi or lady's finger) is an important vegetable crop, valued for its nutritional richness and health benefits. It is low in calories but packed with fiber, vitamins (A, C, K, folate), minerals (magnesium, potassium, calcium), and antioxidants. Its soluble fiber (mucilage) promotes healthy pregnancy and detoxification. Globally, okra holds economic and dietary significance in tropical/subtropical regions, with world production reaching around 13.26 million tonnes in 2024 and India ranked first with 57.99% to global okra production. In India, okra covers an area of approximately 0.563 million hectares, with production at 7.69 million tonnes (2024-25 final estimates) and average productivity of 13.65 tonnes per hectare. Leading states include Gujarat (top in production and area), Madhya Pradesh, West Bengal, Bihar and Odisha. Productivity varies by region, variety, and practices, with potential for higher yields through improved hybrids and management.

This paper evaluates the impact of the okra variety Kashi Kranti, developed by the Indian Institute of Vegetable Research, Varanasi, in 2012. The variety enables farmers to achieve higher per-unit productivity and greater economic returns. The present study adopts an ex-post assessment framework using the economic surplus approach to quantify the economic surplus generated by the research outputs. These estimates are then used to calculate key indicators, including the internal rate of return (IRR), and net present value (NPV). Overall, the study contributes to the discourse on the benefits of Kashi Kranti by highlighting yield gains, cost reductions, and the resulting monetary advantages for producers, consumers, and society.

Okra variety Kashi Kranti has been developed through hybridization between VRO-6 × 67-10-02 followed by pedigree selection at Indian Institute of Vegetable Research (IIVR), Varanasi. It was evaluated in All India Coordinated Research Project on Vegetable Crops at different agroclimatic zones of India. Performing as a superior genotype, it has been released by Central Subcommittee on Crop Standard, Notification and Release of Varieties for Zone IV (Uttar Pradesh, Bihar, Jharkhand and Punjab) as Kashi Kranti through notification no. 2363(E), dated October 4, 2012. It is an early, medium tall (100–115 cm) variety with short internodes along with single or double branch attached in narrow angle with main branch and resistant to yellow vein mosaic virus (YVMV) and okra enation leaf curl virus (OELCV) under field condition. It will take 38 to 42 days for first flowering. Flowering starts after 5 to 6 nodes. Each plant has18 to 20 fruits of dark green colour. The length and diameter of the fruit is 8 to 10 cm and 1.8 cm, respectively at marketable stage. The fruits are available from 45 to 95 days after sowing and total yield is 140 to 150 q/ha. Hence, an attempt has been made to evaluate the economic impact assessment of okra variety Kashi Kranti.

Material and Methods

Using method given by Bisen et al. (2024 and 2025), first, the present rate of the adoption was estimated using the following equation

$$\text{Area}(\text{ha}) = \frac{(1-\text{SCL})}{\text{SR}} * \{\text{BS*SMF}) + \left(\text{Output}_{\text{Gen-1}} * \text{Output}_{\text{seed}} * 1 - (\text{SRR})\right)\} \ldots\ldots(1)$$

Where,
BS is breeder seed supplied by the technology developer (Q), which is taken as 0.55 q per ha); SMF is seed multiplication factor of breeder seed, which taken as 100*100; SR stands for seed required for planting one hectare of land (Q/ha); SRR is Seed replacement rate in the domain region (%), which is assumed as 90%; SCL is Supply chain loss (45%); output Gen-I is first generation output of technology (tonnes), which product of the domain area and yield and output Seed is output kept as seed (%).Using equation 1, the present rate of the adoption can be computed as given the equation 3 as follows.

$$\text{Present rate of adoption (\%)} = \frac{\text{Area}(\text{ha})}{Domain\, area(ha)} * 100 \qquad (2)$$

After estimation of the present rate of adoption (%), and assuming the initial rate of adoption as 0.001%, we traced the path of adoption using the following formula.

To trace the adoption rate of STOVs, we have used S-shaped logistic function

$$A_t = \frac{A_{max}}{1+e^{-(\beta_0+\beta t)}} \ldots\ldots(3)$$

A_t is the adoption rate in t^{th} year after the release of the technology. A_{max} is the technology's maximum adoption rate, which is assumed, as per expert's opinion being an ex-ante analysis, to be around 5% by 2030. It was assumed β_0 and β are the parameters defining the adoption path as it approaches A_{max}. Further, to elicit the values of β_0 and β, two points on the curve are needed. For this analysis, one point was the initial year's adoption rate, which we assumed to be as close to zero as possible, as 0.001%. Furthermore, based breeder seed production data the present rate of adoption, as discussed above, was estimated as 3.71%. The β can be estimated using the equation 3 for each point and then setting them equal using Solver function in MS excel. Then, putting the value β in either of the equation, the value of β_0 can be estimated.

Economic surplus model

we assumed that demand and supply curves are linear. Following Alston et al. (1995) the incremental changes in producer surplus (ΔPS) and consumer surplus (ΔCS) in the closed economy case can be computed using the following equations 13 and 14, respectively.

$$\Delta PS = P_0 Q_0 (K - Z)\, (1+ 0.5\varepsilon_d Z) \qquad (4)$$

$$\Delta CS = Z P_0 Q_0 (1 + 0.5\varepsilon_d Z) \qquad (5)$$

In equation (4) and (5), P_0 is the pre-adoption price of okra; Q_0 is the pre-adoption level of production of okra in the domain area; ε_d is the price elasticity of demand; Z is the relative change/reduction in price, which can be computed as follows.

$$Z = \frac{K\varepsilon_s}{\varepsilon_s + \varepsilon_d} \quad (6)$$

K-shift parameter i.e., shift in the supply function of producers (Alston et al. 1995. This can be estimated using following equation.

$$K = \left(\frac{E(Y)}{\varepsilon_s} - \frac{E(C)}{1+E(Y)} \right) \delta A_t \quad (7)$$

Where, E(Y) = the expected proportionate yield change; $E(C)$ is the expected proportionate cost change; ε_s is the elasticity of supply; δ is the probability that research will achieve the expected yield change (Alston et al. 1995), which is usually taken as unit. Where, ε_s and ε_d is the absolute value of the price elasticity of supply and demand, respectively. The Total economic surplus can be computed using the equation 8:

$$\Delta TS = P_0 Q_0 K(1 + 0.5\varepsilon_d Z) \quad (8)$$

The parameters used in economic surplus model are given in Table 1.

Table 1: Value of the parameters used in estimating of adoption rate and economic surplus

Base year Q (2011-12, 000'ton)	1435	GoI (2018)
Base price P (2012, Rs per ton)	15070	NHB (2012)
Demand elasticity	-0.515	Kumar et al. (2011)
Price elasticity of supply	0.817	Vanitha et al. (2022)
Expected yield change (Scenior-1)	0.15	Field survey
Expected yield change (Scenior-2)	0.25	Field survey
Expected cost change	0.01	Field survey
Technology success probability	1.0	Authors

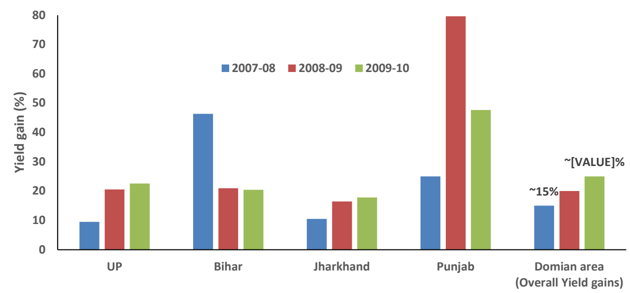

Figure 1: Yield advantage Kashi Kranti over other prevailing varieties

Results and Discussion

Yield advantage of Kashi Kranti over prevailing varieties

The comparative yield advantage of the Kashi Kranti variety over other prevailing varieties across different states 2007–08 to 2009–10 is depicted in Figure 1. In Uttar Pradesh, the yield advantage of Kashi Kranti showed a gradual increase over years. Evidently, the yield gain was approximately 9% in 2007–08, which increased to around 20.5 and 22.6%, respectively in 2008–09 and 2009–10. In Bihar, the highest yield advantage (46.3%) was observed during 2007–08. Despite the decline after the first year, the variety continued to maintain a considerable productivity advantage over the existing cultivars. In Jharkhand, it exhibited relatively moderate but stable gains, on average 14.9%, during the assessment period. Moreover, in the state a gradual rise in the yield gain was recorded, demonstrating the consistency in performance even under comparatively resource-constrained production environments.

Punjab state recorded the highest yield advantage among all the states. The yield gain was approximately 25% in 2007–08, which increased dramatically to nearly 80% in 2008–09 before moderating to around 47% in 2009–10. The exceptionally high yield response in Punjab state suggests that Kashi Kranti performed particularly well under intensive cultivation systems characterized by better irrigation access, higher input use, and improved crop management practices. The overall domain-level (Uttar Pradesh, Bihar, Jharkhand and Punjab) yield advantage demonstrated a positive trend over time. The overall yield gain increased from approximately 15% in 2007–08 to around 20 and 25% in 2008–09 and 2009–10, respectively. This increasing trend indicates the broad-based superiority of Kashi Kranti over prevailing varieties and reflects its increasing acceptance and adaptability across different production ecologies. Considering the above discussion, and to avoid the over-estimate, for estimation of economic surplus, two scenarios of yield gains were assumed, scenario-1 and scenario-2 with yield gains as 15 and 25%, respectively.

Adoption rate of Kashi Kranti variety

The adoption trend of the Kashi Kranti variety exhibited a clear sigmoid growth pattern during the study period from 2012 to 2030. In the initial years from 2012 to 2016, the adoption rate remained low, indicating limited awareness among farmers during the introductory stage. Between 2017 and 2020, the adoption rate increased steadily from nearly 0.15% to about 1.00%. This phase reflects the early diffusion stage where progressive farmers and initial adopters started accepting the technology after observing its potential benefits (Figure 2). The pace of adoption accelerated considerably after 2020, indicating improved awareness, demonstration effects, institutional support, and greater confidence among farming communities. During the period

Table 2: Estimated value of generated economic surplus from Kashi Kranti variety of okra

Particular	*Scenario-I (~15%)*		*Scenario-II (~25%)*	
	2012-2024	*2012-2030*	*2012-2024*	*2012-2030*
Consumer surplus	33.65 (2.59)	53.74 (2.83)	56.23 (4.33)	89.84 (4.73)
Producer surplus	339.80 (26.14)	542.65 (28.56)	567.77 (43.67)	907.24 (47.75)
Economic surplus (ES)	373.45 (28.73)	596.39 (31.39)	624.00 (48.00)	997.08 (52.48)

Note: Figures in parentheses are annualized value of the estimates.

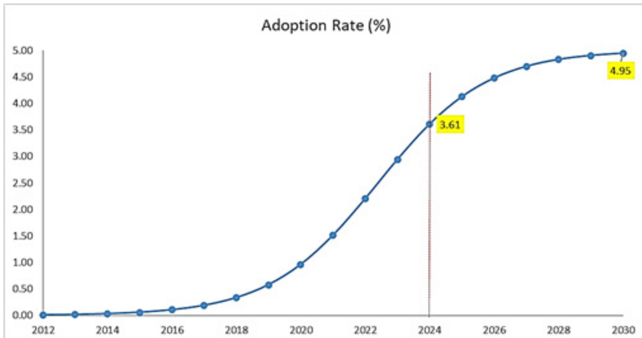

Figure 2: Present and projected rate of adoption of okra variety Kashi Kranti

from 2021 to 2024, the adoption curve showed rapid growth. The adoption rate increased from nearly 1.5% in 2021 to approximately 3.61% by 2024. This stage represents the expansion phase of diffusion where a substantial proportion of farmers adopted Kashi Kranti variety. The sharp rise in adoption during these years suggests that the innovation reached a critical acceptance level among users, possibly due to visible economic advantages, higher productivity, or successful extension interventions. Following this, the adoption level reached around 4.5% by 2026 and further increased to approximately 4.95% by 2030. The projected maximum adoption level of nearly 4.95% by 2030 suggests that the technology is expected to achieve near complete diffusion within the target population under the prevailing conditions.

Under different yield gain scenarios, the estimated economic surplus generated from the adoption of the Kashi Kranti variety of okra indicates substantial welfare gains for both producers and consumers. Keeping the wider variation in yield gains in the domain area of the variety, the analysis was carried out under two scenarios representing 15% and 25% yield advantages over the other prevailing okra varieties, respectively (Table 2). As a part of the *ex-post* analysis, the estimates were generated for period 2012–2024 and, further projected up to 2030 under *ex-ante* analysis. Under scenario-I, the estimated consumer surplus during 2012–2024 was ₹33.65 crore with an annualized value of ₹2.59 crore. The producer surplus was considerably higher at ₹339.80 crore with an annualized contribution of ₹26.14 crore. Consequently, the total economic surplus generated during the same period was estimated at ₹373.45 crore with an average gain of ₹28.73 crore per annum. The higher share of producer surplus in total economic surplus shows that farmers derived the major proportion of benefits from the adoption of the Kashi Kranti variety through increased productivity, and thereby enhanced profitability. The projected estimates up to 2030 under the same scenario further revealed that a substantial increase in benefits, and the total economic surplus is expected to reach ₹596.39 crore with an annualized benefit of ₹31.39 crore. These projections indicate the long-term positive impact of sustained varietal adoption, particularly in the domain area. Under Scenario-II, the estimated benefits are markedly higher because of higher productivity gains as compared to scenario-I. During 2012–2024, consumer surplus was estimated at ₹56.23 crore with an annualized value of ₹4.33 crore, whereas producer surplus reached ₹567.77 crore with an annualized gain of ₹43.67 crore. The overall economic surplus generated during this period was estimated at ₹624.00 crore with an annual average benefit of ₹48.00 crore. The projections up to 2030 under scenario II show that consumer surplus may increase to ₹89.84 crore with an annualized value of ₹4.73 crore, while producer surplus is likely to reach ₹907.24 crore with an annualized gain of ₹47.75 crore. Consequently, the total economic surplus is projected at ₹997.08 crore with an annualized benefit of ₹52.48 crore. Overall, the findings suggest that accelerated adoption of the Kashi Kranti variety can generate substantial economic gains, improve farmer welfare, and contribute significantly to the growth and sustainability of vegetable production in the domain areas.

References

Alston, J.M., Norton, G.W. & Pardey, P.G. (1995) *Science under scarcity: Principles and practice for agricultural research evaluation and priority setting*. Cornell University Press, Ithaca, New York.

Bisen, J.P., Kandpal, A., Jain, R., Mondal, B., Kumar, G.A.K. & Nayak, A.K. (2025) *Economic evaluation of climate-resilient rice varieties*. Policy Paper No. 54. ICAR-National Institute of Agricultural Economics and Policy Research (NIAP), New Delhi.

Bisen, J.P., Mondal, B., Samal, S., Paul, S., Sah, R.P., Anilkumar, C., Verma, R.L., Marndi, B.C., Jambhulkar, N.N., Gowda, B., Pandi, G.P., Kar, M.K., Chakraborti, M., Priyadarsani, S., Mohapatra, S.D., Kumar, G.A.K. & Nayak, A.K. (2024) *Translating science for the benefits of society: The direct and indirect impacts of NRRI*. NRRI Research Bulletin No. 45. ICAR-National Rice Research

Institute, Cuttack, Odisha.

Dudi, B.S. & Sanwal, S.K. (2004) Evaluation of potential F_1 hybrids of tomato (*Lycopersicon esculentum* Mill.) for fruit yield and component traits. *Haryana J Hortic Sci* 33(1-2):98-99.

GoI (2018) Horticultural Statistics at a Glance 2018, Horticulture Statistics Division, Department of Agriculture, Cooperation & Farmers' Welfare, Ministry of Agriculture & Farmers' Welfare, Government of India. New Delhi.

Sanwal, S.K., Singh, S.K., Yadav, R.K., Singh, P.K. & Misra, A.K. (2012) Yield and quality assessment of ginger (*Zingiber officinale* Rosc.) genotypes. *Indian J Plant Genet Resour,* 25(3), 281-286.

Vanitha, S.M., Roy, S. & Singh, N. (2022) Ex-post economic impact assessment of vegetable cowpea var. Kashi Kanchan using economic surplus model. *Veg Sci*, 49(2), 163-168.

सारांश

भिंडी की किस्म 'काशी क्रांति', जिसे भा.कृ.अनु.प.- भारतीय सब्जी अनुसंधान संस्थान, वाराणसी (उत्तर प्रदेश), द्वारा विकसित किया गया है, एक शीघ्र पकने वाली, मध्यम ऊँचाई (100 -115 सेमी), गहरे हरे रंग के फलों वाली (8 -10 सेमी लंबे), उच्च उपज क्षमता वाली (140 -150 क्विंटल हेक्टेयर) तथा येलो वेन मोजेक वायरस (वाई. वी. एम. वी) और ओक्रा एनाशन लीफ कर्ल वायरस (ओ.ई.एल.सी.वी.) के प्रति प्रतिरोधी है। आर्थिक अधिशेष दृष्टिकोण (आल्स्टन और अन्य, 1995) पर आधारित एक एक्स-पोस्ट (पश्चात) और एक्स-एंटे (पूर्व) मूल्यांकन ढांचे का उपयोग करते हुए, इस अध्ययन ने इसके अपनाए जाने (स्वीकृति) के लाभों की माला निर्धारित की। प्रजनक बीज (ब्रीडर सीड) के आंकड़ों और एक एस-आकार के लॉजिस्टिक फंक्शन का उपयोग करके स्वीकृति दरों का अनुमान लगाया गया था, जो 2024 तक लगभग 3.71 प्रतिशत तक पहुंच गई थीं और 2030 तक लगभग 4.95 प्रतिशत तक पहुंचने का अनुमान है। बहु-वर्षीय क्षेत्रीय आंकड़ों (फील्ड डेटा) के आधार पर उपज में वृद्धि के दो परिदृश्यों (प्रचलित किस्मों की तुलना में 15 और 25 प्रतिशत अधिक) का विश्लेषण किया गया। परिणामों ने महत्वपूर्ण सामाजिक-आर्थिक कल्याण लाभ प्रदर्शित किए। परिदृश्य- 1(15 प्रतिशत उपज वृद्धि) के तहत, 2012-2024 तक कुल आर्थिक अधिशेष रू. 373.45 करोड़ (वार्षिकीकृत रू. 28.73 करोड़) था, जो 2030 तक बढ़कर रू. 596.39 करोड़ हो गया। परिदृश्य- 2 (25 प्रतिशत उपज वृद्धि) के तहत, आर्थिक अधिशेष रू. 624.00 करोड़ (2012-2024) तक पहुंच गया और 2030 तक इसके रू. 997.08 करोड़ होने का अनुमान है। उत्पादक अधिशेष का हिस्सा इसमें सबसे प्रमुख था, जो किसानों के लिए उच्च उत्पादकता और बेहतर लाभप्रदता को दर्शाता है। ये परिणाम उत्पादकों, उपभोक्ताओं और समाज के लिए उपज बढ़ाने (पैदावार में वृद्धि), लागत दक्षता (खर्च में कमी), और समग्र आर्थिक लाभ में 'काशी क्रांति' के महत्वपूर्ण योगदान को रेखांकित करते हैं। ऐसी उन्नत किस्मों को तेजी से अपनाने से भारत में सब्जी उत्पादन की स्थिरता मजबूत हो सकती है और छोटे किसानों की आजीविका को सहायता मिल सकती है।