

Bridging the yield gap in onion production: economic potential in arid Kachchh of Gujarat

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Summary

Onion (*Allium cepa* L.) is an important vegetable crop with considerable potential for improving farm income in arid regions. However, its productivity is often constrained by limited adoption of improved varieties and recommended crop management practices. The present study evaluated the performance of frontline demonstrations (FLDs) on hybrid onion 'Rosy' conducted by ICAR–CAZRI, Krishi Vigyan Kendra (KVK), Bhuj–Kachchh-II, Gujarat, during the rabi seasons of 2013–14 to 2015–16. A total of 37 demonstrations covering 14.8 ha were conducted in nine villages of Anjar and Bhuj talukas to compare the improved production technology with prevailing farmers' practices. The demonstrated technology recorded an average bulb yield of 266.04 q ha⁻¹, compared with an average yield of 211.00 q ha⁻¹ under farmers' practices, resulting in a reported average annual yield advantage of 26.06%. The yield advantage increased from 24.20% in 2013–14 to 27.55% in 2015–16. The average technology gap, extension gap and technology index were 33.96 q ha⁻¹, 55.04 q ha⁻¹ and 11.32%, respectively. The declining technology gap and technology index indicated improved performance of the demonstrated technology under farmers' field conditions. In addition, five training programmes and field days reached more than 650 farmers, supporting the dissemination of improved onion production practices. The findings highlight the potential of FLDs as an effective extension approach for demonstrating improved varieties and crop management technologies, enhancing onion productivity and promoting technology adoption under the arid agro-climatic conditions of Kachchh, Gujarat.

JAE 2025, Vol 21

Received: 20 December 2025

Accepted: 27 December 2025

Published: 31 December 2025

<https://doi.org/10.58628/JAE-2521-115>

Associated Editor: Dr. PS Kumar

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Keywords: Adoption, frontline demonstration, gross return, net return, onion, technology gap, technology index

Introduction

Onion (*Allium cepa* L.), a prominent bulbous vegetable belonging to the family Amaryllidaceae, is among the oldest cultivated crops globally Warade et al. (2008). Valued for its distinct flavor, pungent aroma, and cultural significance, it is a foundational ingredient in diverse culinary traditions. Beyond its culinary appeal, the onion has a rich history in traditional medicine, with therapeutic applications documented in ancient texts such as the *Charaka Samhita*. Modern research continues to validate these historical claims, confirming that onions contain bioactive compounds responsible for potent antioxidant, antimicrobial, and health-promoting properties Choudhary (1999) and Hiremath and Nagraju (2010). Consequently, the crop plays a vital role in human nutrition and international agricultural trade. Originating in Central Asia with the Near East serving as a secondary center of diversity Singh and Varshney (2010), the onion is cultivated extensively across the globe. In India, short-day varieties hold particular significance due to their adaptation to local agro-climatic conditions and their high market preference for pungency and flavor. As the world's second-largest onion producer after China, India relies heavily on this crop for agricultural income, employment generation, and foreign exchange earnings.

Nationally, onions are cultivated across roughly 1.62 million hectares, yielding 26.64 million tonnes with an average productivity of 16.40 t ha⁻¹ Anonymous, (2021). In Gujarat, the crop occupies 99,413 ha, recording a production of 2,464,611 tonnes and a productivity of 247.9 q ha⁻¹ Anonymous, (2018). Major producing states include Maharashtra, Karnataka, Madhya Pradesh, Gujarat, Rajasthan, Andhra Pradesh, and Tamil Nadu, underscoring the critical need to sustain and elevate productivity. Despite high aggregate production, onion cultivation frequently faces constraints such as the use of low-yielding varieties, a scarcity of quality seed, suboptimal water and nutrient management, and low adoption rates of modern technologies (Haldhar & Meena 2026). While choosing a high-yielding variety is foundational, its benefits must be unlocked through balanced fertilization, precise irrigation scheduling, timely planting, weed control, and integrated pest management. However, a significant gap often persists between the agricultural technologies generated by research institutes and their actual implementation by farmers, driven by inadequate extension mechanisms and limited awareness (Samadia & Haldhar 2019; Haldhar et al. 2018). Frontline Demonstrations (FLDs) serve as a vital extension tool to bridge this gap. Implemented under the aegis of the Indian Council of Agricultural Research (ICAR) and Krishi Vigyan Kendras (KVKs), FLDs allow farmers to directly observe the performance of improved

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technologies under local conditions, comparing them side-by-side with traditional practices. These demonstrations promote the adoption of high-yielding varieties, quality seeds, balanced nutrition, and integrated management, while generating vital feedback on real-world production constraints and extension gaps Verma et al, (2010). To address regional productivity challenges under the arid agro-climatic conditions of the Kachchh district, ICAR–CAZRI Krishi Vigyan Kendra (KVK, Bhuj, Gujarat) conducted frontline demonstrations evaluating the high-yielding hybrid variety 'Rosy' alongside a scientifically recommended package of practices. This study was undertaken to evaluate the yield performance, economic returns, technology gap, extension gap, and technology index of the demonstrated intervention relative to standard farmers' practices. Ultimately, the findings aim to highlight the efficacy of FLDs in boosting onion productivity and accelerating technology adoption in fragile arid ecosystems.

Materials and Methods

The present study was conducted by ICAR–CAZRI, Krishi Vigyan Kendra (KVK), Bhuj–Kachchh-II, Gujarat, during the rabi seasons of 2013–14 to 2015–16 in farmers' fields. A total of 37 frontline demonstrations (FLDs) were established over an aggregate area of 14.8 ha in nine villages, namely Jambudi, Khambra, Kotda Chakar, Kukma, Lohariya, Pantiya, Ratnal, Reldi Nani and Tharawada, located in Anjar and Bhuj talukas of Kachchh district, Gujarat. The district lies within the arid agro-climatic region of Gujarat and is characterized by challenging soil and climatic conditions. The soils at the study sites were predominantly saline to alkaline, with pH ranging from 7.5 to 8.5 and electrical conductivity (EC) from 0.9 to 2.2 dS m⁻¹. Soil organic carbon content varied from 0.12 to 0.75%, indicating low to medium levels. Available nitrogen and potassium ranged from 169 to 302 kg ha⁻¹ and 134 to 472 kg ha⁻¹, respectively, while available phosphorus was generally low to medium. The onion hybrid 'Rosy' was selected for the demonstrations, and its seeds were procured from the National Seeds Corporation Limited (NSC) and supplied

to the participating farmers. Before the commencement of the demonstrations, KVK scientists, particularly the Subject Matter Specialist (Horticulture), organized village-level training programmes on nursery raising and integrated crop management in onion. These programmes aimed to enhance farmers' knowledge and skills in adopting recommended production technologies. To strengthen technology dissemination and encourage collective learning, KVK Kukma, Bhuj, also facilitated the formation of an interested onion growers' group in collaboration with the Department of Agriculture (DoA) and the Agricultural Technology Management Agency (ATMA). During the study period, five training programmes and field days were organized, reaching more than 650 farmers and sensitizing them to improved onion varieties and recommended agronomic practices. The FLDs were implemented by comparing the recommended production technology using hybrid 'Rosy' with the prevailing farmers' practices, which served as the control or check treatment. The technological interventions adopted in the demonstration plots and the corresponding farmers' practices are presented in Table 1. The demonstrations were conducted following the recommended procedures for FLD implementation according to Gaharwar and Ughade (2018), including the selection of suitable beneficiaries and demonstration sites, timely provision and effective utilization of critical inputs, and active participation of farmers throughout the demonstration process. KVK scientists regularly visited the demonstration fields from nursery establishment to crop harvesting to monitor the implementation of recommended practices, provide technical guidance and ensure timely execution of crop management operations. Data on bulb yield, cultivation costs, gross returns, net returns and the benefit–cost ratio were collected from the demonstration plots and farmers' practice plots. The yield obtained under the demonstrated technology was compared with that under farmers' practices and with the potential yield of the selected hybrid to assess the yield differences and identify the technological and extension gaps.

Table 1. Difference between technology intervention and farmers' practices under FLD on onion in the study area

S. No.	Operation	Farmer's practice	Improved technology demonstrated	Gap
1.	Soil and water testing	Not in practice	Done in all locations	Full gap
2.	Variety	Local	Hybrid Rosy	Full gap
3.	Seed treatment	None	Trichoderma 10g/kg seed	Full gap
4.	Seed rate	14 kg/ha	7 kg/ha	Partial gap
5.	Sowing method	Flat Bed	Raised Bed	Partial gap
6.	Manure & Fertilizer application	Without recommendation	FYM: 20-25 t/ha 100:50:50 kg NPK/ha. Half N & full P ₂ O ₅ and K ₂ O applied at the time of transplanting and half dose of N 1 month after TP.	Partial gap
7.	Weeding	One Hand weeding	Pre-emergence weedicide application of oxyfluorfen 23.5% EC 0.1-0.15 kg a.i./ha + 1 Hand Weeding at 45 DAT	Partial gap
8.	Micronutrient Spray	Micronutrient spray not practised	2 foliar sprays of micro mix @ 0.25% containing (Zn:6%, Fe:4%, Cu:0.5%, Mn:1%, B:0.5%)	Full gap

9.	Plant Protection measures	Only chemical spray without recommendation	Integrated pest and Disease management practices applied	Partial gap
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Descriptive statistical tools, including frequencies and percentages, were used wherever applicable to summarize the relevant data. The economic performance of the demonstrated technology was evaluated using cultivation costs and monetary returns, while the technology gap, extension gap and technology index were calculated following the approaches described by Samui et al. (2000).

The following formulae were used to estimate the technology gap, extension gap, technology index, additional returns and benefit–cost ratio:

Technology gap = Potential yield - Demonstration yield

Extension gap = Demonstration yield - Farmers practice yield

Additional return = Demonstration return- Farmers practice return

Technology index = [(Potential yield - Demonstration yield)/Potential yield] x 100

Benefit cost ratio (BCR) =
$$\frac{\text{Grossreturn (Rsha}^{-1}\text{)}}{\text{Totalcostofcultivation (Rsha}^{-1}\text{)}}$$

Results and Discussion

Bulb Yield Performance

The results of the frontline demonstrations (FLDs) demonstrated a positive impact on the farming

community, motivating growers to adopt improved agricultural technologies. As detailed in Table 2, the data clearly reveal that the demonstrated technology consistently outperformed the local check plots in onion bulb yield across all three years of the study. The maximum average onion bulb yield (266.04 q ha⁻¹) was achieved under the improved practice, recording an average yield increase of 26.06% over the local check (210 q ha⁻¹). These findings are in line with those reported by Gaharwar et al.(2017) and Gaharwar and Ughade (2018), Gupta et al.(2015), Hiremath and Nagaraju (2010), Kumar (2014), and Warade et al. (2006), in onion crops. Similar yield enhancements through FLDs in other horticultural crops have also been documented by Ramniwas et al. (2022) in drumstick, and Singh et al. (2011) in solanaceous vegetables. The higher crop yields obtained in the demonstration plots confirm the technical feasibility and suitability of the hybrid onion variety 'Rosy' under the agro-climatic conditions of the Kachchh district. This pronounced yield enhancement can be attributed to the genetic superiority of the high-yielding hybrid variety coupled with scientific interventions such as integrated nutrient and weed management, as similarly noted by Warade et al. (2008).

Table 2. Year wise details and yield performance of onion under frontline demonstrations

Year	No. of Demo	Area (ha)	Yield (q ha ⁻¹)			Increased yield over local check (%)
			Potential Yield (PY)	Demo Yield (IP)*	Check Yield (FP)	
2013-14	17	6.8	300	254.62	205	24.20
2014-15	10	4.0	300	268.00	212	26.42
2015-16	10	4.0	300	275.50	216	27.55
Average			300	266.04	211	26.06

*IP=Improved Practice; FP= Farmers Practice

Technology Gap Analysis

The technology gap is of great significance than other cultivation parameters as it indicates the constraints in implementation and drawbacks in our package of practices with respect to environmental or varietal change. The technology gap is the difference between demonstration yields over potential yield. From the data presented in Table 3, the technology gap was ranged from 24.50 to 45.38q/ha, with an average of 33.96 q/ha during the study period. The yield gap between

demonstrated technology and potential yield needs to be minimized with the conduct of FLD/s. The variation in technology gap during the demonstration years may be due to varied soil fertility, climatic conditions of the area and management practices implemented by the farmers. Hence, more location-specific recommendations and precise use of technology in the fields are necessary to bridge the technology gap as supported by Singh et al. (2011).

Table 3. Extension gap, technology gap and technology index of onion under FLDs

Year	Technology Gap (q ha ⁻¹)	Extension Gap (q ha ⁻¹)	Technology Index (%)
2013-14	45.38	49.62	15.13
2014-15	32.00	56.00	10.67
2015-16	24.50	59.50	08.17
Average	33.96	55.04	11.32

Extension Gap Analysis

Baseline assessments revealed that most farmers predominantly relied on traditional practices rather than high-yielding variety seeds and optimized agronomic

packages, leading to a substantial extension gap between recommended technologies and standard farm operations. To address this disparity, KVK introduced improved onion production technologies across various

farmer fields through frontline demonstrations, successfully boosting bulb yield over local checks. As detailed in Table 3, the extension gap between the demonstration plots and the local checks varied from 49.62 to 59.50 q ha⁻¹. This pronounced margin was primarily attributed to the historical under-adoption of high-yielding varieties and modern crop management techniques. Such a wide gap underscores the urgent need to raise farmer awareness regarding superior cultivars and integrated production packages to elevate overall productivity. These findings align with previous observations emphasizing that progressive integration of improved technologies can reverse widening extension gaps through targeted educational outreach and systematic extension planning. Furthermore, these results corroborate the insights of Mukherjee (2003), who highlighted that location-specific problem identification followed by tailored interventions holds profound implications for enhancing crop productivity.

Technology Index Analysis

The technology index shows the feasibility of the technology in the farmer's field. The technology index reported in Table 3, showed a decreasing trend of technology index values from 15.13 to 8.17%, showed the feasibility of demonstrated technology during the demonstration years. The average technology index value 11.32% might be due to précised use of demonstrated technologies in the field and suitable climatic conditions during the demonstration period. As technology index denotes the gap between technology generated at research farm and farmer's field, lower the technology index more feasible will be the technology Hiremath and Nagraju (2010). The findings of Choudhary et al. (2018) on the impact of FLDs on fennel (Abu Sonf) also supported the study.

Conclusion

The frontline demonstrations (FLDs) conducted during the rabi seasons of 2013–14 to 2015–16 established the effectiveness of hybrid onion 'Rosy' combined with improved crop management practices under the agro-climatic conditions of Kachchh, Gujarat. The demonstrated technology recorded an average bulb yield of 266.04 q ha⁻¹, representing a reported yield advantage of 26.06% over farmers' practices. The average technology gap, extension gap and technology index were 33.96 q ha⁻¹, 55.04 q ha⁻¹ and 11.32%, respectively. The declining technology gap and technology index over the three years indicated improved performance of the demonstrated technology under farmers' field conditions. Furthermore, the organization of five training programmes and field days, reaching more than 650 farmers, in collaboration with the Department of Agriculture and ATMA strengthened technology dissemination and awareness of improved onion production practices. Overall, the findings highlight the potential of FLDs as an effective extension approach for demonstrating improved technologies, narrowing yield differences between recommended and prevailing farming practices, and promoting the adoption of high-yielding onion varieties. Wider dissemination of hybrid 'Rosy', supported by timely availability of quality seed,

location-specific agronomic recommendations and continuous technical guidance from KVKs, may contribute to enhanced onion productivity and farm profitability in the arid region of Kachchh.

Acknowledgements

The authors acknowledge the support of the Director, ICAR-ATARI, Pune Zone VIII, Project Director, ATMA Bhuj, and ICAR-CAZRI KVK Bhuj, and the technical staff for assistance during field experimentation.

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