

Impact assessment of frontline demonstrations on productivity and economic returns of drumstick (*Moringa oleifera* Lam.) in Arid Kachchh, Gujarat

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Summary

Drumstick (*Moringa oleifera* Lam.) is a multipurpose horticultural crop valued for its edible pods and nutritional potential. Frontline demonstrations (FLDs) are an important extension approach for assessing improved technologies under farmers' field conditions. ICAR–CAZRI, Krishi Vigyan Kendra (KVK), Kukma, Bhuj, conducted demonstrations during 2016–17 and 2017–18 in villages of Bhuj and Bhachau talukas, Kachchh district, Gujarat, to compare the performance and economics of the improved cultivar Bhagya (KDM-1) with farmers' local practice. The manuscript reports average pod yields of 197.80 q ha⁻¹ under demonstrations and 158.88 q ha⁻¹ under farmers' practice, a reported increase of 24.50%. The average extension gap, technology gap and technology index were 3,892 kg ha⁻¹, 5,220 kg ha⁻¹ and 20.88%, respectively. The reported additional net return was ₹57,630 ha⁻¹, and the benefit: cost ratio under the improved practice was 4.82, compared with 3.92 under farmers' practice. Associated training programmes, farmer–scientist interactions and field days reached more than 550 farmers. These results indicate promising productivity and economic outcomes under the conditions observed; however, adoption rates and changes in farmers' knowledge were not quantified in the available study data.

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Keywords: Arid region; drumstick; frontline demonstration; economic returns; technology gap; technology index

Introduction

Drumstick (*Moringa oleifera* Lam.) is a highly nutritious, multipurpose vegetable crop cultivated extensively across India, particularly in the southern states. Recognized for its rapid growth, it has been reported to reach heights of 6 to 7 meters within a single year even in regions receiving less than 400 mm of mean annual rainfall. India is the prime producer of moringa with an annual production of 2.2 million tonnes of tender fruits from an area of 43,600 ha leading to the productivity of around 50 tonnes per ha. Due to wider adaptability and resistance to drought, it can be cultivated on variety of soils and climatic conditions without much care. It is used to treat malnutrition in children younger than three years. About six spoonfuls of leaf powder can meet a woman's daily iron and calcium requirements, during pregnancy. Hence, the moringa plant can be considered a powerhouse of nutritional value.

The Kachchh region of Gujarat is characterized by extreme aridity, featuring an average annual rainfall of approximately 340 mm distributed across roughly 13 rainy days. With nearly 95% of precipitation concentrated between June and September and high inter-annual variability, the region is highly vulnerable to drought, which severely constrains the selection of horticultural crops. While drumstick's drought tolerance and ability to produce marketable pods under warm conditions make it a promising candidate for evaluation, its actual field

performance depends heavily on local soil conditions, irrigation availability, and crop management. To evaluate the crop's suitability against these environmental constraints, the Krishi Vigyan Kendra (KVK) organized systematic field surveys, farmer training sessions, exposure visits, and frontline demonstrations of an improved cultivar paired with a recommended package of practices. The economic performance of the crop was assessed by comparing cultivation costs, gross and net returns, and benefit-cost ratios under prevailing Kachchh conditions (Haldhar et al. 2018; Haldhar and Meena 2026).

Despite drumstick's theoretical suitability for dryland horticulture, rigorous field-level evidence evaluating improved cultivars through structured frontline demonstrations under the specific arid environment of Kachchh is notably limited. Traditional farming practices frequently rely on uncertified local cultivars devoid of optimized agronomic inputs, resulting in wide yield gaps and suboptimal economic returns (Samadia & Haldhar 20219). The novelty and significance of this study lie in addressing this critical extension gap. By systematically comparing the high-yielding improved cultivar Bhagya (KDM-1) against farmers' local practices across two consecutive growing seasons, this study generates empirical data on productivity, profitability, and input-output dynamics. Furthermore, by documenting the outcomes alongside structured farmer-outreach activities, the findings provide actionable baseline evidence to bridge adoption barriers, refine regional

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horticultural guidelines, and inform future extension planning in fragile arid ecosystems.

Materials and Methods

The study was conducted by ICAR–CAZRI, Krishi Vigyan Kendra, Bhuj–Kachchh-II, Gujarat, during 2016–17 and 2017–18 at farmers' fields. The manuscript's Table 1 lists five demonstrations covering 2.0 ha in each year; this total should be verified against the original field records before submission. The soils of the farmer's field were sandy loam with a pH of 7.8 to 8.6, OC -0.35 to 0.55% and low in available phosphorus and medium in available potash. The total rainfall of 139.8 mm on 6 rainy days and 290 mm on 13 rainy days were received in 2016-17 and 2017-18, respectively. The variety used for the study was Bhagya (KDM-1) is recommended by the University of Horticultural Sciences, Bhagalkot for its early bearing, self-pruning type and high yield and quality pods of 60-70 cm long. For the successful cultivation of this crop, a spacing of 3.0 x 2.5 m was followed with a population of 1333 plants per hectare. The raised beds were prepared 10 days before of sowing and then the seeds are sown at the right spacing. The seeds were germinated within 10 to 12 days after sowing. The pre-sowing seed treatment of was done with Azospirillum culture resulted in early germination and increased seedling vigor, growth and yield. For irrigation and fertigation purpose almost all the farmers used drip irrigation system. When the trees reached 75 cm height from the ground level, pruned the apical growing shoot (10 cm from the top) with the help of a sharp cutting knife, to encourage the development of many branches and pods within easy reach from the ground. After harvest the trees were cut down to a height of 1 meter above ground level for ratooning. During the ratooning operation, the plants are fed with recommended level of N, P and K nutrients (250:125:125 g NPK/tree) along with 10-12 kg plant⁻¹ FYM. During the life cycle of the crop, there was not any serious disease or insect pest observed, however at some places leaf eating caterpillars and bud worm observed during September and October months which were controlled by two foliar spray of Lambda-cyhalothrin 5 EC @ 0.3 ml/lit. Of water.

Table 1. Year-wise details and yield performance of frontline demonstrations in drumstick

Year	No. of Demo	Area (ha)	Yield (q ha ⁻¹)			Increased yield over local check (%)
			Potential Yield (PY)	Demo Yield (IP)*	Check Yield (FP)	
2016-17	05	2.0	250.00	185.70	155.86	19.11
2017-18	05	2.0	250.00	209.90	161.90	29.65
Average			250.00	197.80	158.88	24.50

*IP=Improved Practice; FP= Farmers Practice

A pod yield of 6.71 t ha⁻¹ at first picking itself on cv Bhagya (KDM-1) was reported by Math et al., (2014). Singh et al., (2017) reported a marketable pod yield of 19.1 t ha⁻¹, the first year itself from farmer's field, whereas Jadhav et al., (2010) observed a yield level of

The FLDs were used to look the differences in potential yield and demonstration yield, as well as the extension gap and technology index. In this impact study, yield data was obtained from FLD plots and local farming practices widely used by farmers in this region, for comparative analysis. Statistical tools such as frequency and percentage were used to collect, tabulate, and analyse the data. The extension gap, technology gap, and technology index were calculated using the Samui et al. (2000) equations.

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) =

$$\frac{\text{Gross return (Rs ha}^{-1}\text{)}}{\text{Total cost of cultivation (Rs ha}^{-1}\text{)}}$$

Results and Discussion

Pod Yield Performance

Pod yield under the improved cultivar *Bhagya* (KDM-1) was compared descriptively with yield under farmers' local practice (Table 1). The manuscript does not report plot-level observations, measures of variability, or an inferential statistical test; therefore, the yield difference should be interpreted as a descriptive comparison rather than as a statistically significant effect. The reported yield was 185.70 and 209.90 q ha⁻¹ in 2016–17 and 2017–18, respectively, compared with 155.86 and 161.90 q ha⁻¹ under farmers' practice.

The higher average pod yield recorded in demonstration plots coincided with the use of the improved cultivar *Bhagya* (KDM-1) and the recommended package of practices, including seed treatment, spacing, weed management, irrigation and nutrient management, and need-based plant protection. Because the intervention combined several components and the study did not isolate their individual effects, the yield difference cannot be attributed to any single component.

30.44 t ha⁻¹ of cv PKM-1 under no fertilizer and 51.6 t ha⁻¹ when potash at 25 g/tree was applied. A yield potential of 50.5 t ha⁻¹ of cv PKM-1 was also reported by Singh (2010)

Table 2. Extension gap, technology gap and technology index of drumstick under FLDs

Year	Technology Gap (kg ha ⁻¹)	Extension Gap (kg ha ⁻¹)	Technology Index (%)
2016-17	6430	2984	25.72
2017-18	4010	4800	16.04
Average	5220	3892	20.88

Technology Gap Analysis

The technology gap serves as a critical indicator, highlighting potential constraints in field execution and highlighting areas where recommended packages of practices may need adjustment due to local environmental or varietal shifts. Defined as the variance between potential yields and those achieved in demonstration plots, this metric spanned from 4,010 to 6,430 kg ha⁻¹ maintaining a mean of 5,220 kg ha⁻¹ across the study duration (Table 2). Such fluctuations in the technology gap are primarily driven by localized microclimatic variations, uneven soil fertility profiles, differences in irrigation water quality, shifting pest and disease pressures, and varying levels of crop management skill among growers. These observations align closely with previous field-level findings reported by Mitra and Samajadar (2010) and Kumar et al. (2021).

Extension Gap Analysis

The extension gap represents in table 2, the difference between the demonstration yield and the yield under farmers' practice. In this study, it ranged from 2,984 to 4,800 kg ha⁻¹, averaging 3,892 kg ha⁻¹. The results indicate scope for extension efforts to improve access to and understanding of suitable cultivars and recommended production practices. However, the study did not quantify baseline knowledge or subsequent adoption among individual farmers. This large extension gap emphasized that there was a need to educate the farmers through various means i.e. front-line demonstration for the adoption of improved production and protection technologies, to revert the trend of wide extension gap. More and more use of the latest production technologies with improved variety, drip and fertigation will subsequently change this alarming trend of galloping extension gap. The findings of Bhoraniya et al. (2017), Mishra et al. (2019) and Ngullei and Biswas (2016) corroborate the conclusions of this study.

Technology Index Analysis

The technology index evaluates the practical feasibility and field-level adoptability of an introduced technology, sharing an inverse relationship with its acceptance rate—meaning that lower index percentages denote higher feasibility and farmer adoption (Sagar and Chandra, 2004). As shown in Table 2, the technology index touched a high of 25.72% in 2016–17 and dropped to 16.04% in 2017–18, resulting in a combined average of 20.88%. The lower index value recorded in the second year can be attributed to enhanced plant health, favorable seasonal soil dynamics, and optimal climatic conditions. Overall, these low index figures indicate strong local acceptability and smooth technological integration, echoing similar impact findings from Chauhan et al. (2020), Dayanand et al. (2012), and Raj et al. (2013)

Economic Analysis

According to the Table 3, the economic performance of the demonstrated technology was compared with farmers' practice using cultivation cost, gross return, net return, additional return and benefit: cost ratio. The demonstration plots recorded average gross and net returns of ₹296,700 and ₹235,200 ha⁻¹, respectively, compared with ₹238,320 and ₹177,570 ha⁻¹ under farmers' practice. The reported additional net return was ₹57,630 ha⁻¹, and the benefit:cost ratio was 4.82 under improved practice and 3.92 under farmers' practice. The higher additional returns under demonstrations could be due to improved technology, timely crop cultivation operations and scientific monitoring of the crop. Singh et al. (2017) while analyzing the economic sustainability of drumsticks in Gujarat, observed that drumsticks gave an average of total return of Rs 5,37,972.60 kg ha⁻¹ with a B:C of more than 10 in 10-year crop duration. More and less similar results were also reported by Hiremath et al. (2007), Ngullei and Biswas (2016), Venkatesan et al. (2018), Sakdeo et al. (2019) in different fields crops.

Table 3. Economic analysis of frontline demonstrations on drumstick farming

Year	Cost of cultivation (Rs/ha)		Gross Return (Rs/ha)		Net Return (Rs/ha)		Additional Return (Rs ha ⁻¹)	B:C Ratio	
	IP*	FP	IP	FP	IP	FP		IP	FP
2016-17	61000	59500	278550	233790	217550	174290	43260	4.57	3.92
2017-18	62000	62000	314850	242850	252850	180850	72000	5.08	3.92
Average	61500	60750	296700	238320	235200	177570	57630	4.82	3.92

*IP=Improved Practice; FP= Farmers Practice

Field-Day Demonstration and Farmer Outreach

To boost technology diffusion and encourage widespread regional adoption, KVK Kukma (Bhuj) partnered with the Department of Horticulture and ATMA

to organize structured farmer-scientist dialogues, specialized training modules, and field days. Across the study timeline, these collaborative extension events successfully reached and engaged upwards of 550

growers. During these field days, attendees had the opportunity to directly evaluate the growth characteristics and pod performance of the demonstrated crop under optimized management protocols. KVK experts systematically walked participants through key technological components, including high-yielding variety selection, proper row and plant spacing, pre-sowing seed treatments, precise drip irrigation usage, canopy management and pruning techniques, integrated nutrient dosing, and ratoon management. Interactive discussions were held directly with attending farmers to review realized yield potentials, overall crop health, and bottom-line economic advantages.

Conclusions

The frontline demonstrations successfully provided empirical, field-level evidence demonstrating the superior yield and economic viability of the improved drumstick cultivar Bhagya (KDM-1) under the extreme arid conditions of Kachchh, Gujarat. Across the two consecutive study seasons, the demonstration plots recorded a significantly higher average pod yield (197.80 q ha^{-1}) compared to traditional farmer practices (158.88 q ha^{-1}), translating to an average yield enhancement of 24.50%. The technical evaluation revealed an average technology gap of $5,220 \text{ Kg ha}^{-1}$ and an extension gap of $3,892 \text{ kg ha}^{-1}$, underscoring the critical need to bridge local adoption shortfalls through structured technology transfer. Furthermore, a favorable low average technology index of 20.88% highlighted the high practical feasibility and strong local acceptability of the intervened technology among farming communities. From a financial perspective, the improved practice generated substantial economic returns, yielding an average net return of ₹235,200 ha^{-1} an additional average net return of ₹57,630 ha^{-1} over local practices—alongside a highly remunerative benefit-cost ratio of 4.82. Additionally, extension outreach efforts through collaborative farmer-scientist interactions, training modules, and field days successfully reached over 550 growers, fostering heightened awareness and promoting horizontal technology diffusion. While these findings strongly support the wider regional dissemination and adoption of improved drumstick production packages in fragile arid ecosystems, future assessments should incorporate structured follow-up surveys to rigorously track long-term adoption rates, knowledge gain, and plot-level variations.

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