Impact through frontline demonstrations on yield, yield gap and economics of drumstick farming in arid Kachchh of Gujarat

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Summary

Drumstick (*Moringa oleifera* L.) is one of the world's most nutritious crops and is one of the most popular vegetables grown throughout India. It has helped mankind in combating malnutrition in children and increasing immunity. Front-line demonstration (FLDs) is one of the most popular tools for technology transfer. ICAR-CAZRI, Krishi Vigyan Kendra, Kukma, Bhuj conducted field studies for two consecutive years of 2016-17 and 2017-18 through frontline demonstrations (FLDs) on yield and economics of drumstick farming in different villages of Bhachau and Bhuj Talukas of Kachchh, Gujarat. This tree is easy to cultivate, resistant to drought and produces a high concentration of protein, vitamins and minerals. It is a rare horticulture crop which begins fruiting within six months of planting and continues to do so for a period of eight to nine years. In Kachchh, Gujarat, the crop has been just introduced owing to its suitability in arid conditions of the region. The average pod yield under demonstration was 197.80 q ha^{-1} compared to the farmer's local variety (158.88 q ha^{-1}) and increased significantly by 24.50% on average over farmers used variety. The average extension gap, technology gap and technology index were 3892 kg ha^{-1}, 5220 kg ha^{-1} and 20.88%, respectively. By adopting improved variety, farmers get additional average returns of Rs. 57,630 ha^{-1} and B: C ratio of 4.82.

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INTRODUCTION

Drumstick (*Moringa oleifera* L.) is one of the nutritious and popular vegetable crops, especially in the southern part of India. It is a fast-growing tree and has been found to grow to 6-7 m in one year in areas receiving less than 400 mm mean annual rainfall.[19] India has a diverse culture; hence the drumstick goes with many region-specific names; Muringakkai, Muringakkaya, Munnakaya, Munaga, Nuggekai in southern states, shevaga, sheng, saragvani sing, saragavo in the western region and Sajjan Ki Phalli, Segva, Shinga, Saigan, Sehijjan, Munaga in northern states. 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.[30] Among the different states, Andhra Pradesh leads in both area and production (15,665 ha) followed by Tamil Nadu (13,042 ha) and Karnataka (10,280 ha).[30] Moringa grows in sunny climates and wherever sufficient water and sunshine are available. It grows in tropical and subtropical regions. Flowering in drumsticks varies from place to place and is greatly influenced by rain, temperature, humidity, wind, soil temperature, soil moisture etc. It cannot sustain extreme cold and frost. It provides pods, flowers and leaves for vegetables and has various nutraceutical values. Pods are 60 to 70 cm long and 140 g to 150 g in weight. Fruits are green-coloured and highly pulpy. The first harvest starts 160 to 170 days after planting and on an average, each tree bears 150 to 225 fruits per year. This tree is easy to cultivate by seed (low variability) or asexually (cuttings) means. Due to wider adaptability and resistance to drought, it can be cultivated on variety of soils and climatic conditions without much care.[3] It can tolerate a wide range of annual rainfall (250 mm- 3000 mm) and pH (5.0-9.0).[22] It provides pods, flowers and leaves for vegetables and has various nutraceutical

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values. Moringa is rich in nutrition owing to the presence of a variety of essential phytochemicals present in its leaves, pods and seeds. Moringa is said to provide seven to ten times more vitamin C than oranges, ten times more vitamin A than carrots, 17 times more calcium than milk, 9 times more protein than yoghurt, 15 times more potassium than bananas and 25 times more iron than spinach.[21] It is used to treat malnutrition in children younger than three years.[17] About six spoonfuls of leaf powder can meet a woman's daily iron and calcium requirements, during pregnancy.[6] Hence, the moringa plant can be considered a powerhouse of nutritional value.[15] The ripened seed powder can be used to clear the water by precipitating muddy and dusty substances in rural areas.[1]

The Kachchh region of Gujarat experiences arid climatic conditions with an average annual rainfall of 340 mm in just 13 rainy days. About 95 per cent of the total rainfall occurs in June-September. The variations in the timing and quantity of rainfall are very high having a co-efficient of the variability of about 60 per cent. This unreliability and uncertainty of rainfall have made Kachchh susceptible to droughts. The annual average relative humidity of the area is 63 per cent. The evapo-transpiration rate is as high as 250 to 270 mm per month. Under these conditions, drumstick is fitted the best crop due to low water requirement, drought resistance and adaptable to harsh soil and environmental conditions.

The demand for this crop in India has increased considerably. The soil and climatic conditions of Gujarat are better suited for its cultivation and would gain a successful establishment in all agroclimatic zones of Gujarat. At present as well as future, it's increasing demand in our country for nutritional diet. Its cultivation would fetch greater returns to our farmers thus, this crop would help double the farmer's income.

Keeping this in view, the farmers were motivated to grow this cash crop by organizing field surveys, exposure visit, farmers' training, field demonstrations of improved cultivars with a package of practices. The economic sustainability of the crop in the region was also demonstrated by computing cost, net returns and other economic parameters under Kachchh conditions.

Materials and Methods

The current study was conducted by the ICAR-CAZRI, Krishi Vigyan Kendra, Bhuj-Kachchh-II (Gujarat) for two consecutive years of 2016-17 and 2017-18 at farmer's fields. A total of 5 frontline demonstrations were conducted on 2.0 ha area in various villages namely Bhujodi, Lakhond, Madhapar and Lakadyia of Bhachau and Bhuj Talukas of the Kachchh district. The Kachchh district is bounded by 23°24' to 23°46' North latitudes and 69°38'to 31°58' East longitudes. The total geographical area of Kachchh district is 45652 sq. km divided into ten talukas which is the largest district in Gujarat as well as in India.

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 vigour, 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 the 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 budworms were observed during the September and October months which were controlled by two foliar sprays of Lambda-cyhalothrin 5 EC @ 0.3 ml/lit. of water. The FLDs were used to look at 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)[26] and Sagar and Chandra (2004)[24] 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

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

Results and Discussion

Pod Yield Performance

The field performance using improved variety of drumstick bhagya was analysed statistically for yield performance at farmers' fields in FLD plots and farmers used local variety (Table 1). It was observed that there is an increase in the pod yield of drumsticks with the introduction of improved variety intervention in a demonstration as compared to the farmer's local variety practice. High pod yield (185.70 and 209.90 q ha^{-1} respectively, in 2016- 17 and 2017-18) was recorded in FLD *i.e.,* 19.11 and 29.65 per cent higher than farmer's local variety. On average, the cultivar Bhagya produced a marketable pod of 197.80 q ha^{-1}, which was 24.5% higher than that produced by the farmer's local cultivar (158.88 q ha^{-1}).

The results clearly indicated that the higher average pod yields in demonstration plots compared to the farmer's practice were achieved due to knowledge and adoption of the improved package of practices including the latest high-yielding variety seed (Bhagya), seed treatment, spacing, weed management, irrigation management, nutrition management and need-based plant protection measures.

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 was reported by Math et al., (2014)[12]. Singh et al., (2017)[29] reported a marketable pod yield of 19.1 t ha^{-1}, the first year itself from farmer's field, whereas Jadhav et al., (2010)[9] observed a yield level of 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).[27]

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 is of great significance than other cultivation parameters as it indicates the constraints in implementation and drawbacks in our package of practices concerning environmental or varietal change. The technology gap is the difference between demonstration yields over potential yields. The technology gap ranged from 4010 to 6430 kg ha^{-1}, with an average of 5220 kg ha^{-1} during the study period. The technology gap may be attributed to the dissimilarity in the soil fertility, quality of irrigation water, surrounding microclimate, insect-pests and disease risk, level of crop management by farmers and others are responsible for the changes in this gap. Similar findings were found by Mukherjee (2003)[16], Mitra & Samajadar (2010)[13] and Kumar et al. (2021)[11].

Extension Gap Analysis

Before the study period, it was discovered that most farmers did not use high-yielding variety and optimized packages of practices for drumstick cultivation, resulting in an extension gap between demonstrated technology and farmers' exercise. To bridge that gap, KVK demonstrated improved drumstick cultivation technology on farmers' fields as FLDs, which resulted in increased marketable pod yield over the farmer's practice. The data presented in the Table 3 showed the wide extension gap between improved and conventional practice varied between 2984 and 4800 kg ha^{-1}, with an average of 3892 kg ha^{-1}, according to data acquired from the FLDs. 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)[2], Mishra et al. (2019)[14], Ngullei and Biswas (2016)[18] and Parmar et al. (2020)[20] corroborate the conclusions of this study.

Technology Index Analysis

The technology index shows the feasibility of the evolved technology at the farmer's field. The acceptability and practicality of technology are always inversely proportional to the technology index; the higher the acceptability of the demonstrated technology, the lower the technology index value (Sagar and Chandra, 2004)[24]. According to the data collected the lowest technology index at 16.04 per cent in 2017-18 and at highest 25.72 per cent in 2016-17 with an average was 20.88 per cent. During the study period, the lowest technology index in 2017-18 may be due to the better health of the plants. In addition to this, soil and climatic conditions are also responsible factors in that year. The technology index showed that the intervention technology was widely accepted by the farmers. The findings of Chauhan et al. (2020)[4] Dayanand et al. (2012)[5], Kale et al. (2020)[10], Raj et al. (2013)[23] and Singh (2018)[28] on the impact of FLDs in different crops are in agreement with the current studies.

Economic Analysis

It is essential to assess the economical yardstick of the demonstrated drumstick technology as compared to existing farmer's technology. The cost of inputs and output statistics for drumstick production under frontline demonstrations were gathered and analyzed to determine gross return, the net return, additional income and the benefit-cost (B:C) ratio. The results of the economic analysis of drumstick production revealed that front-line demonstration recorded an average gross return and net return of Rs. 2,96,700 and Rs. 2,35,200 ha^{-1} compared to farmer's practice of Rs. 2,38,320 and Rs. 1,77,570 ha^{-1}. Furthermore, the demonstration plots produced an average additional return of Rs. 57,630 ha^{-1} and a higher average benefit-cost ratio of 4.82. 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)[29] while analyzing the economic sustainability of drumsticks in Gujarat, observed that drumsticks gave an average of total return of Rs 5,37,972.60 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)[7], Hiremath & Nagaraju (2010)[8] and Ngullei & Biswas (2016)[18], Sakedo et al. (2019)[25] in different fields crops.

Table 3: Economic analysis of front-line 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

Conclusion

The front-line demonstration is the most suitable method for assessing the performance of the improved technology as it directly involves the scientists in conducting the demonstrations at the farmers' field which enables them to have first-hand information related to the technology. Technological and extension gap extended can be bridged by an improved package of practices with an emphasis on improved variety, seed treatment, balance nutrient application and proper use of plant protection measures. Replacement of local variety with an improved variety of drumsticks would increase the production and net income of the farmers. Hence, the concept of FLD may be applied at more farmers' fields for speedy and wider dissemination of the recommended practices which will subsequently improve the livelihood of the farming community.

Declaration of interests

The authors have no conflict of interest to declare.

Data sharing

All relevant data are within the manuscript.

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