Impact through a front-line demonstration on yield and economics of fennel (*Foeniculum vulgare* Mill) in arid Kachchh of Gujarat

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Summary

It is customary in India to offer fennel seeds after a meal and eating fennel seeds after a meal is considered a healthy practice, primarily because of its ability to keep the digestive system healthy. Seed spices played an important role in the Indian economy under agricultural commodities for a long time. Front frontline demonstrations (FLDs) on Fennel were organized by ICAR-CAZRI, Krishi Vigyan Kendra, Kukma, Bhuj in different villages of Anjar and Bhuj Talukas of Kachchh from 2019-20 to 2021-22. The high-yielding variety Gujarat Fennel-12 was evaluated at the farmer's field under the front line demonstration programme (FLDs). A total of 60 demonstrations were conducted in 24 ha area at farmer's fields against farmer's practice in arid Kachchh of Gujarat. The average seed yield under improved practice was 2160 kg ha^{-1} compared to the farmer's practice (1770 kg ha^{-1}) and increased significantly by 22.08% on average over the farmer's practice output. The average extension gap, technology gap and technology index were 390.00 kg ha^{-1}, 240.00 kg ha^{-1} and 10.00%, respectively. Through adopting improved practices, farmers get additional average returns of Rs.22562 ha^{-1}. During this period the extension activities like farmer's training, distribution of literature, diagnostic visits etc. were taken to provide instant benefit to the farmers. Frontline demonstrations programme created greater awareness, attitude and skill to adopt improved practices of Fennel and therefore, increased their production and economics.

JAE 2022, Vol 14
Received: 15 Oct. 2022
Accepted: 31 Oct. 2022
Published: 05 Nov. 2022
https://doi.org/10.53911/JAE.2022.14217

Associate Editor: Dr. S. M. Haldhar

Keywords: Arid; frontline demonstration; fennel; gross return; technology gap; technology index

INTRODUCTION

India is known as the "Land of Spices" across the world for a long. It is the largest producer, consumer as well as exporter of spices and spice products in the world. Gujarat is a leading producer of seed spices particularly Fennel, Coriander, Cumin, Isabgol and Dill. Fennel (*Foeniculum vulgare* Mill) commonly known as 'Saunf' belongs to the family Apiaceae (Umbelliferae) and is believed to be a native of Southern Europe and the Mediterranean region. It is one of the most seed spices in India mainly grown in Gujarat and Rajasthan, which is mainly used in culinary and pharmaceutical preparations. To the ancient Greeks, fennel represented success and so it was called "Marathon" in reference to the battle, fought in a fennel field where the Greeks defeated the Persians in 490 B.C. Fennel is used in various traditional systems of medicine like in Ayurveda, Unani, Siddha in the Indian and Iranian traditional systems of alternative and balancing medicine.[25] The seeds are rich in protein (9.5%), minerals and vitamins. The seeds contain essential oil, which is used as a flavouring agent in the manufacturing of pickles, cakes perfumes, soap, liquors and cough drops. Its seeds contain 0.7 to 1.9% volatile oil in which the chief constituent is an ethole (50-70%). The volatile oil is used for manufacturing cordials and fennel water which is given to infants as medicine. Fennel seeds are typically known to naturally increase the number of fluids inside the breast tissue. They not only add firmness to breasts, but also lead to an increase in breast size. Fennel is extensively used as galactagogues for improving the milk flow of breastfeeding mothers[12]. Its decoction is also given to women for blood purification and uterus cleaning. Fennel seeds have been used as an ingredient for removing any foul smell from the mouth[14]. Dried fennel seeds are often used in various digestive problems including heartburn, bloating, loss of appetite and colic in

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infants. India is the largest producer of fennel which is cultivated in a 78.976 thousand-hectare area with a production of 127.160 thousand tonnes and productivity of 1610 kg ha^{-1}.[1] The fennel seeds were exported to the tune of 33741.50 tonnes values worth Rs. 29396.40 lakh from India during 2020-21.[2] Gujarat is the largest producer of fennel in the country producing 75540 tonnes from the 41970 hectare area with productivity of 1799.91 kg ha^{-1} (Anonymous, 2020-21c).[3] In Gujarat state, it is mainly cultivated in Surendranagar, Banaskantha, Mehsana, Aravali, Patan and Kachchh districts.

The main objective of FLDs is to demonstrate newly released crop production and protection technologies and their management in the farmers' field under different agro-climatic regions.[29, 32] Frontline demonstration (FLD) is one of these programmes, which focuses on increasing productivity by providing vital inputs as well as improved packages of practices that have been tested by scientists from ICAR Institutes and State Agricultural Universities (SAUs). The yields are higher when high-yielding variety seed, recommended seed rate, seed treatment, planting time, appropriate fertiliser dose, weed control, and integrated pest and disease management are used, as opposed to farmer's practices. Other key aspects of this initiative include promoting the farming of improved varieties, receiving feedback from farmers concerning barriers to the adoption of recommended improved technologies for further research, and maximising the technology diffusion process among farmers.[22]

Keeping in mind these considerations, KVK conducted FLDs in farmers' fields to encourage the adoption of the high-yielding variety Gujarat Fennel-12 as well as an improved package of practices in the arid Kachchh, with the goal of increasing productivity and increasing net profit from this crop. The current study seeks to investigate the Yield Gap, Technological Gap, Extension Gap, Technology Index, and Yield Gap between FLD plots and farmers' practices, as well as the level of technology adoption and economics of the technology.

Materials and Methods

The current study was conducted by the ICAR-CAZRI, Krishi Vigyan Kendra, Bhuj-Kachchh-II (Gujarat) during the rabi, 2019-20 to 2021-22 at farmer's fields. A total of 60 frontline demonstrations were held throughout a 24.0 ha area in various villages namely Bhujodi, Chapredi, Dhaneti, Dhori, Kukma, Khambra, Kotda Chakar, Chubdak, Jawaharnagar, Modsar, Nana Reha and Reldi of Anjar and Bhuj Talukas of the Kachchh district. The Kachchh district is bounded by 23º24′ to 23º 46′ North latitudes and 69º38′to 31º58′ 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 average annual rainfall is registered at 250-340 mm and about 95 per cent of the total rainfall occurs during June-September. The number of rainy days are very few; the annual average is only 13 days. 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. Winds are generally moderate to high with an annual wind speed of 11.3 km per hour. Winter and summer temperatures range from 7- 48^{0}C with an average humidity of 63 per cent annually and increase to 80 per cent during the south-west monsoon. The soils in the study area were primarily saline and alkaline in nature with pH values 7.8 to 9.0, EC ranging from 0.9 to 2.6 dSm^{-1} and low to medium in organic carbon (0.12-0.70%). Nitrogen and potassium in the soil varied from 169-301 and 134 to 470 kg/ha, with low to medium quantities of phosphorus. The practices adopted for the current study comprised high yielding variety of Gujarat Fennel-12 (Released by SDAU, Dantiwada, Gujarat) with an improved package of practices, where existing farming techniques were viewed as a local check or farmer's practice (FP). Line sowing of the crop was done in the third and fourth week of October with a recommended spacing of 45x15 cm. Seed treatment was done with *Trichoderma viridae* @ 10 g per kg seed. The crop was fertilized with recommended dose of fertilizers *i.e.* 90 kg N and 30 kg P_2O_5 per hectare. Full dose of phosphorus and half dose of nitrogen were applied as basal doses and the remaining half dose of nitrogen was applied at 35 and 65 DAS. In addition to this, one foliar spray of chelated EDTA-Zn and EDTA-Fe @ 0.3% was given during the flowering stage. For weed control applied soil application of pendimethalin @ 1.0 kg/ha as pre-emergence and followed by one-hand weeding at 35 DAS. During the life cycle of the crop, there is not any serious disease or insect-pest observed. However, in some places aphid is observed and controlled by two foliar sprays of neem oil as a precautionary measure in the field. 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 along with local farming practices widely used by farmers in this region for comparative analysis. During the off-campus training and field trips, KVK scientists assisted the demonstration farmers by demonstrating methods such as sowing in rows, spraying, weeding, and harvesting. 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)[28] and Sagar and Chandra (2004)[27] 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

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

Results and Discussion

Seed yield performance: The results indicated that frontline demonstrations have given a good impact over the farming community as they were motivated for adoption of new agriculture technology applied in the demo plot. The study revealed from the Table-1 that improved technology performed better and produced an average seed yield of 2160 kg ha^{-1} in comparison to local check (1770 kg ha^{-1}) over three years, where the potential yield of Fennel (Gujarat Fennel-12) was 2400 kg ha^{-1}. The improved practice also registered a mean seed yield of 22.08 percent increase over the farmer's practice. It was evident from the yield levels recorded in demonstrations that the improved package of practices can boost the yield significantly. The results clearly indicated that the higher average seed yields in demonstration plots compared to the farmer's practice were achieved due to knowledge and adoption of the improved package of practices including latest high-yielding variety seed (GF-12), sowing time, seed rate, seed treatment, sowing method, spacing, weed management, irrigation management, and need-based plant protection measures. The similar trends of yield enhancement under frontline demonstration in Fennel and other seed spices reported by Choudhary et al. (2018)[7], Dhaka et al. (2015)[10], Garwal and Arora (2013)[11] Lal et al. (2016)[17], Meena et al. (2016)[20], Poonia et al. (2017)[23], Tamboli et al. (2020)[31] and Verma et al. (2016)[33].

Table 1: Year-wise details and yield performance of frontline demonstrations (Average of three years)

Year	No. of Demo	Area (ha)	Yield (kg ha^{-1})			Increased yield over local check (%)
			Potential Yield (PY)	Demo Yield (IP)*	Check Yield (FP)	
2019-20	10	4.0	2400	2300	1850	24.32
2020-21	30	12.0	2400	2050	1650	24.24
2021-22	20	8.0	2400	2130	1810	17.68
Average			2400	2160	1770	22.08

*IP=Improved Practice; FP= Farmers Practice

Table 2: Extension gap, technology gap and technology index of coriander under FLDs

Year	Technology Gap (Kg ha^{-1})	Extension Gap (Kg ha^{-1})	Technology Index (%)
2019-20	100	450	4.17
2020-21	350	400	14.58
2021-22	270	320	11.25
Average	240	390	10

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 to environmental or varietal change. The technology gap is the difference between demonstration yields over potential yields. The technology gap ranged from 100 to 350 kg ha^{-1}, with an average of 240 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 farmer's and others are responsible for the changes in this gap. Similar findings were found by Kumar et al. (2021)[15], Mitra and Samajadar (2010)[19] and Mukherjee (2003)[21].

Extension Gap Analysis

Before the study period, it was discovered that the most farmers did not use high-yielding variety seeds and optimised packages of practices for Fennel cultivation, resulting in an extension gap between demonstrated technology and farmers' exercise. To bridge that gap, KVK demonstrated improved Fennel cultivation technology on various farmers' fields as FLDs, which resulted in increased seed 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 320 and 450kg ha^{-1}, with an average of 390 kg ha^{-1}, according to data acquired from the FLDs. This large extension gap emphasized that there was a need to raise awareness about the use of high-yielding varieties in conjunction with a better package of techniques to increase productivity. The extension gap was recorded at its lowest (320 kg ha^{-1}) in the concluding year 2021-22, indicating the greater adoption of superior technologies of the KVK. The findings of Bhoraniya et al. (2017)[5], Lal et al. (2013)[16] and Singh et al. (2011)[30] corroborate the conclusions of this study.

Technology Index Analysis

The technology index shows the feasibility of the 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). According to the data collected the lowest technology at 4.17 per cent in 2019-20 and at highest 14.58 per cent in 2020-21 with an average was 10 per cent. During the study period, the lowest technology index in 2019-20 may be due to better monitoring of the grower's field as the numbers of FLDs are lesser. In addition to this, soil and climatic conditions are also responsible factors in that year. The technology index showed that the intervened technology was widely accepted and viable by the farmers. The findings of Choudhary et al. (2018)[7], Chauhan et al. (2020)[6], Dayanand et al. (2012)[8], Mishra et al. (2009)[18] and Raj et al. (2013)[24] 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 fennel technology as compared to existing farmer's technology. The net return varies yearly due to changes in input cost, labour charges and the sale price rate of the produce. The cost of inputs and output statistics for fennel production under frontline demonstrations were gathered and analysed to determine gross return, the net return, additional income, and the benefit-cost (B:C) ratio. The outcomes of the economic analysis (Table 3) of fennel cultivation revealed that an average gross return and net return of Rs. 140767 and Rs. 98833 ha^{-1} compared to farmers' practice of Rs. 116510 and Rs. 74983 ha^{-1}. Furthermore, the demonstration plots produced an average additional return of Rs. 22562 ha^{-1} and a higher average benefit-cost ratio of 3.30. The higher additional returns under demonstrations could be due to improved technology, timely crop cultivation operations and scientific monitoring of the crop.

Table 3: Economic analysis of front-line demonstrations on Fennel

Year	Cost of cultivation (Rs/ha)		Gross Return (Rs/ha)		Net Return (Rs/ha)		Additional Return (Rs/ha)	B:C Ratio	
	IP*	FP	IP	FP	IP	FP		IP	FP
2019-20	36500	36075	103500	83250	67000	47175	15960	2.84	2.31
2020-21	38500	38125	127100	102300	88600	64175	24425	3.30	2.68
2021-22	50800	49300	191700	162900	140900	113600	27300	3.77	3.20
Average	41933	41167	140767	116150	98833	74983	22562	3.30	2.73

*IP=Improved Practice; FP= Farmers Practice

The results of the economic study point to the shown technology's increased profitability and economic feasibility. Choudhary et al. (2018)[7], Jain (2018)[13] and Rathore and Mathur (2020)[26] in fennel and Singh et al. (2011)[30] in seed spices found similar results. Bhargav et al. (2015)[4] and Dhaka et al. (2010)[9] all reported similar findings in chickpea and maize.

Conclusion

The three years study reveals that fennel variety (GF-12) has given encouraging results over local variety and has the potential to perform well with time management practices in the arid condition of Kachchh, Gujarat. The production enhancement and quality improvement under frontline demonstrations can improve growers' attitudes, skills, knowledge and competence. This also led to improving the relationship between farmers and scientists. The beneficiary farmers always play an important role as a source of information and dissemination of the high-yielding variety of Fennel for other nearby farmers. This will help remove the cross-sectional barriers among the farming community. FLDs are a critical role in pushing farmers to adopt modern agricultural technology, resulting in increased output and income. Farmers can attain a higher additional return with a lower additional input cost by using this technology.

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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Preferred citation: Ramniwas, Kanwat M & Jat SR. 2022. Impact through a front-line demonstration on yield and economics of fennel (*Foeniculum vulgare* Mill) in arid Kachchh of Gujarat. *Journal of Agriculture and Ecology*, 14: 125-130; http://doi.org/10.53911/JAE.2022.14217