The Pharma Innovation Journal 2022; 11(11): 542-546

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(11): 542-546

www.thepharmajournal.com
Received: 02-08-2022
Accepted: 06-09-2022

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Impact of adoption of improved variety on yield and economics of fenugreek (*Trigonella foenum-graecum* L.) in arid Kutch of Gujarat

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Abstract
Fenugreek is an important seed spice crop in arid region of India particularly in Rajasthan and Gujarat states. To popularize the improved variety of fenugreek in arid Kutch of Gujarat ICAR-CAZRI, Krishi Vigyan Kendra, Kukma, Bhuj were organized Front frontline demonstrations (FLDs) in different villages of Anjar and Bhuj Talukas in the district for three years. Under the demonstration fields, seeds of improved variety (AFg-3) along with all improved package and practices of fenugreek applied. During the practice a total 20 demonstrations were conducted in 8 ha area at the farmers field. The average seed yield under improved variety was 2311.67 kg ha^{-1} compared to the farmer's local variety (2070 kg ha^{-1}) and increased significantly by 11.68% an average over farmers used variety. The average extension gap, technology gap and technology index were 241.67 kg ha^{-1}, 88.33 kg ha^{-1} and 3.68%, respectively. Through adoption of improved variety, farmers get additional average returns of Rs. 8718.33 ha^{-1} and B: C ratio 2.75. During this period extension activities like farmers 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 Fenugreek and therefore, increased their production and economics.

Keywords: Arid, frontline demonstration, fenugreek, gross return, technology gap, technology index

Introduction
Fenugreek (*Trigonella foenum-graecum* L.) is a popular seed spice crop belonging to subfamily *Papilionaceae* of the family *Fabaceae* (Suleiman, *et al*., 2008) [22]. Fenugreek is an annual self-pollinated herbaceous plant, commonly known as 'methi' and grown predominantly for leaves, shoots and seeds during *rabi* season in north-western India. It has high medicinal value and is an important multiuse crop as every part of it is consumed in various forms. The pods and leaves are rich source of iron, calcium, protein and vitamins. The seeds are mainly used as flavoring agent in many vegetable preparations and having high medicinal and nutraceutical value. Fenugreek seed contains gums (20.06%), mucilage (28%), trigonelline (0.13-0.30%), and saponin (1.7%) with 370 calories per 100 g calorific value (Budaavari, 1996) [5]. It also contains good percentage of protein (9.5%), fat (10%), crude fiber (18.5%), carbohydrate (42.3%) and many other minor nutrients and vitamins. The extract of fenugreek is a potential source of alternative medicine with high free radical scavenging ability that can be used for therapeutic purposes (Choudhary *et al*., 2017) [8]. Rajasthan and Gujarat contribute more than 80 per cent of the total seed spices production in the country. This belt can, therefore be called as "seed spices bowl" of the country. India is the largest producer of fenugreek seed which is cultivated on 121.327 thousand hectare land area with a production of 202.631 thousand tonnes and productivity of 1670 kg / ha (Anonymous 2021a) [1]. The fenugreek seeds were exported from the India to the tune of 26750 tonnes values worth Rs. 15690 lakh during 2020-21 (Anonymous, 2021b) [2]. In Gujarat state Fenugreek is cultivated in an area of 9005 ha with a production of 16.947 thousand tonnes and productivity of 18.80 kg / ha (Anonymous, 2020-21c) [3].

The farmers of Kutch district are growing fenugreek since long back using local or low yielding varieties without adopting standard package of practices. Farmers of some pockets are still following practice of broadcasting for sowing which poses hurdle in intercultural operations during crop growth period. It reduces both quality and yield of fenugreek. Therefore, front line demonstration programme was an effective tool for increasing the productivity of crop and changing knowledge, attitude and skill of farmers.

The main objective of Front Line Demonstrations is to demonstrate newly released crop variety, production and protection technologies and its management practices on the farmers field under different agro-climatic conditions and farming situations (Singh and Varshney, 2010; Verma, *et al.*, 2010) [20, 23]. KVKs Scientists/SMS are organizing regularly on-campus and off-campus training programmes for the benefits of farmers and farm women in order to make them aware about new crop technologies.

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 adoption of recommended improved technologies for further research, and maximising the technology diffusion process among farmers (Nagarajan *et al.*, 2001) [15].

FLDs are organized in a block of 2 to 5 hectares involving all those farmers whose plots fall in the identified demonstration block. Only critical inputs and training are provided from the scheme budget, remaining inputs are supplied by the farmers themselves. The purpose is to be convince extension functionaries and farmers together about the potentialities of the technologies for further wide scale diffusion and Front Line demonstration are used as a source of generating data on factors contributing higher crop yield and constraints of production under various farming situation. The present study was carried out with following specific objective effect of front line demonstration on yield enhancement of fenugreek cultivation in arid zone of Gujarat.

Keeping in mind of these considerations, KVK conducted FLDs in farmers' fields to encourage the adoption of the high-yielding variety AFg-3 as well as an improved package of practices in the arid Kutch, 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.

Methodology

The current study was conducted by the ICAR-CAZRI, Krishi Vigyan Kendra, Bhuj-Kutch-II (Gujarat) during the rabi season for three years i.e., 2017-18, 2019-20 and 2020-21 at farmer's fields. A total of 20 frontline demonstrations were held on 8.0 ha area in various villages namely Modsar, Bhujodi, Madhapar, Ler, Nana Reha, Kotda Chakar, Vadva and Reldi of Anjar and Bhuj Talukas of the Kutch district. The Kutch district is bounded by 23º24' to 23º 46' North latitudes and 69º38'to 31º58' East longitudes. The total geographical area of Kutch district is 45652 sq. km divided into ten talukas which is the largest district in the Gujarat as well as in the India. The average annual rainfall is registered 250-340 mm and about 95 per cent of total rainfall occurs during June-September. Number of rainy days is very few, annual average is only 13 days. The variations in the timing and quantity of rainfall are very high having co-efficient of variability of about 60 per cent. This unreliability and uncertainty of rainfall has made Kutch 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 °C with an average humidity of 63 per cent annually and increase to 80 per cent during south-west monsoon. The soils in the study area were primarily saline and alkaline in nature with pH value 7.6 to 8.6, EC ranging from 0.8 to 2.4 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 quantity of phosphorus.

Randomly selected farmers were allotted these FLD's to make aware about scientific interventions being developed for yield maximization. The FLD programme was implemented with high yielding variety AFg-3 (Released by ICAR-NRCSS, Tabiji, Ajmer, Rajasthan) with improved package of practices for 3 years. Each demonstration was conducted in 0.4 hectares area with an equal area of control plot with farmers' practice. The performance of latest improved variety AFg-3 was compared with local variety grown by the farmers. The characteristic feature of this AFg-3 variety is bold seeded, long pod length and matures in 130-135 days. Recommended package of practices were adopted in both demonstration as well farmers' practice.

Before organizing the demonstrations, skill oriented training programmes were conducted by KVKs in the selected villages as per the technological needs. The demonstrations were monitored by the KVK scientists through frequent visits during cropping seasons.

The crop was sown during first fortnight of November and harvested in the mid of March during all the three years. Seed treatment was done with Trichoderma viridae @ 10 g per kg seed. The crop was fertilized with recommended dose of fertilizers *i.e.* 20 kg N and 40 kg P_2O_5 per hectare. For weed control applied soil application of pendimethalin @ 500 g / 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 and insect pest observed, however some places aphid observed and managed by two foliar spray of neem oil as precautionary measure in the field. Powdery mildew also observed on some farmers field and for the control of this disease dusting with sulphur dust @ 20 kg / ha.

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 variety 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 [19] and Sagar and Chandra, 2004 [18] 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

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

Results and Discussion

Seed Yield Performance

The field performance by the use of improved variety of fenugreek AFg-3 was analyzed statistically for yield performance at farmer's field in FLD plot and farmers used local variety (Table 1). It was observed that there is an increase in the seed yield of fenugreek with introduction of improved variety intervention in demonstration as compared to farmer's local variety practice. High seed yield (2325, 2270 and 2340 kg ha^{-1} respectively, in 2017- 18, 2019-20 and 2020-21) was recorded in FLD's *i.e.*, 10.71, 10.19 and 14.15 per cent higher than farmer's local variety. Overall, average seed yield produced in demonstration was 11.68 per cent higher as compared to farmer's local variety.

The results clearly indicated that the higher average seed yields in demonstration plots compared to farmer's practice were achieved due to knowledge and adoption of the improved package of practices including latest high yielding variety seed (AFg-3), sowing time, seed rate, seed treatment, sowing method, spacing, weed management, irrigation management, and need-based plant protection measures. The similar trends of yield under frontline demonstration in fenugreek and other seed spices reported by Mehriya *et al.*, 2020 [13]; Lal, *et al.*, 2017 [12], Dashora *et al.* 2020 [9]; Meena *et al.*, 2016 [14]; Poonia *et al.*, 2017 [16] and Verma *et al.*, 2016 [24].

Table 1: Year wise details and yield performance of frontline demonstrations in fenugreek

Year	No. of Demo	Area (ha)	Yield (kg ha^{-1})			Increased yield over local check (%)
			Potential Yield (PY)	Demo Yield (IP)*	Check Yield (FP)	
2017-18	10	4.0	2400	2325	2100	10.71
2019-20	05	2.0	2400	2270	2060	10.19
2020-21	05	2.0	2400	2340	2050	14.15
Average			2400	2311.67	2070	11.68

*IP = Improved Practice; FP = Farmers Practice

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

Year	Technology Gap (Kg ha^{-1})	Extension Gap (Kg ha^{-1})	Technology Index (%)
2017-18	75	225	3.13
2019-20	130	210	5.42
2020-21	60	290	2.5
Average	88.33	241.67	3.68

Technology Gap Analysis

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. The technology gap was ranged from 60 to 130 kg/ha, with an average of 88.33 kg/ha during the study period. Such a gap might be attributed to the adoption of high yielding varieties sown with the help of seed cum fertilizer drill with balanced nutrition and appropriate plant protection measures in demonstrations which resulted in higher grain yield than the traditional farmers' practices. These results are in agreement with the findings of Lal, *et al.*, 2013 [11] and Singh, *et al.*, 2011 [21].

Extension Gap Analysis

Prior to the study period, it was discovered that the majority of farmers did not use high yielding variety seeds and optimised packages of practices for Fenugreek cultivation, resulting in an extension gap between demonstrated technology and farmers' exercise. To bridge that gap, KVK demonstrated improved Fenugreek cultivation technology on various farmers' fields as FLDs, which resulted in increased seed yield over the farmers practice. The data presented in the Table-2 showed the wide extension gap between improved and conventional variety use varied between 210 and 290kg ha^{-1}, with an average of 241.67 kg ha^{-1}, according to data acquired from the FLDs. The difference in the extension gap found due to lack of awareness about the use of improved variety which is high yielding and resistance to pests and diseases. The findings of Bhoraniya *et al.*, 2017 [4]; Lal *et al.*, 2013 [11] and Singh *et al.*, 2011 [21] corroborate the conclusions of this study.

Technology Index Analysis

The technology index shows the feasibility of the demonstrated of varietal trails at the farmer's field. The acceptability and practicality of a 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) [18]. Data in (Table-2) revealed that the technology index of AFg-3 variety of fenugreek was minimum (2.5%) in the year 2020-21 as compared to the years 2019-20 (5.42%) and 2017-18 (3.13%). On average technology, the index was observed at 3.68 percent during the three years. It shows the efficacy of good performance of technical interventions. The findings of Patel *et al.*, 2022 [17]; Choudhary *et al.*, 2018 [7], and Chauhan *et al.*, 2020 [6] on the impact of FLDs in different crops are in agreement with the current studies.

Economic Analysis

It is essential to assess the economical yard stick of the demonstrated fennel technology as compared to existing farmer's technology. The net return varies from year to year due to changes in input cost, labour charges and 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, net return, additional income, and the benefit cost (B:C) ratio. The outcomes of the economic analysis (Table-3) of fenugreek cultivation revealed that an average gross return and net return of Rs. 140766.67 and Rs. 98833.33 ha^{-1} compared to farmers practice of Rs. 116510 and Rs. 74983.33. Furthermore, the demonstration plots produced an average additional return of Rs. 22561.67 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 operations of crop cultivation and scientific monitoring of the crop. Economic analysis exhibited that improved variety of AFg-3 and recommended practices significantly increased the gross and net returns during all the years. The outcomes of the economic analysis (Table-3) of fenugreek cultivation under demonstration revealed that an average gross return and net return of Rs. 90151.67 and Rs. 57451.67 ha^{-1} compared to farmers practice of Rs. 80533.33 and Rs. 48733.33. Furthermore, the demonstration plots produced an average additional return of Rs. 8718.33 ha^{-1} and a higher average benefit cost ratio of 2.75.

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

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
2017-18	30000	28800	81375	73500	51375	44700	6675	2.71	2.55
2019-20	33700	33300	90800	82000	57100	48700	8400	2.69	2.46
2020-21	34400	33300	98280	86100	63880	52800	11080	2.86	2.59
Average	32700	31800	90151.67	80533.33	57451.67	48733.33	8718.33	2.75	2.53

*IP = Improved Practice; FP = Farmers Practice the results of the economic study point to the shown technology's increased profitability and economic feasibility. Dhaka *et al.*, 2010 [10] reported similar findings in chickpea and maize

Conclusions

Results of three years study reveals that fenugreek variety (AFg-3) have given encouraging results over local variety and have potential to perform well with timely management practices in arid condition of Kutch, Gujarat. It can be concluded that the FLDs programs were effective in changing attitude, skill, knowledge of improved packages and practices of adaptation of HYV of fenugreek with low cost. The enhancement of productivity under the front line demonstration over the traditional method of fenugreek cultivation created greater awareness and motivated the other farmers to adopted appropriate production technology of fenugreek in the district. FLDs serve a critical role in pushing farmers to adopt modern agricultural technology, resulting in increased output and income.

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