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Impact of adoption of scientific interventions in fenugreek on grain yield and farmers income: An assessment by FLD's in Arid Zone of Rajasthan, India

G. Lal

National Research Center on Seed Spices, Ajmer-305206, Rajasthan, India.

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Fenugreek is one of the major seed spice crop grown in India and mainly cultivated in the state of Rajasthan. The crop occupies about 94000 ha area with annual production of 116000 tonnes (2011-12). Front line demonstrations (FLDs) on fenugreek with three interventions (improved varieties, line sowing and seed treatment) were conducted at Farmers' fields of adopted village Alniawas in district Nagaur of Rajasthan state during winter season of the years 2009 to 2010, 2010 to 2011 and 2011 to 2012. On the basis of three years' overall average, it is inferred that about 23.51 higher grains yield was recorded under FLDs than that of the farmers' traditional check/ practice. The study exhibited mean extension gap of 299 kg ha-1, technology gap of 929 kg ha-1 with mean technology index of 37.16%. An additional investment of Rs. 1400 ha-1 coupled with recommended nutrient, water management, plant protection measures, scientific monitoring and non-monetary factors resulted in additional mean returns of Rs. 8970 ha-1. The overall average Incremental benefit: Cost ratio was calculated as 6.41.

Key words: Economics, fenugreek, front line demonstrations (FLDs), gap analysis, grain yield.

INTRODUCTION

Fenugreek (*Trigonella foenum graecum* L.) commonly known as *Methi,* is an important self pollinated seed spice crop belonging to subfamily *Papilionaceae* of the family *Fabaceae* (Suleiman et al., 2008). It is native of South Eastern Europe and West Asia and has been part of North African Countries, Argentina, France, Morocco and Lebanon. India is the major producer of fenugreek and its production is concentrated mainly in the states of Rajasthan, Madhya Pradesh, Maharashtra, Punjab, Gujarat and Uttar Pradesh. The major districts growing fenugreek in Rajasthan are Sikar, Chittorghar, Jaipur, Pali, Nagaur, and Alwar. In India the area under fenugreek is 94000 ha with production of 116000 tonnes and average national productivity (yield) is 1200 kg/ha during 2011-12 (Anonymous, 2012). The seeds are mainly used as flavoring agent in many vegetable preparations and having high medicinal and neutraceutical value. Fenugreek seed contains protein (9.5%), fat (10%), crude fiber (18.5%), carbohydrate (42.3%) and many other minor nutrients and vitamins.

E-mail: glal67@yahoo.co.in; Tel: +91-9414609649.

It also contains good percentage of gums (20.06%), mucilage (28%), trigonelline (0.13 to 0.30%), and saponin (1.7%) with 370 calories per 100 g calorific value (Budaavari, 1996).

The average productivity of fenugreek in India is remaining less (1200 kg ha^{-1}) in spite of making tremendous efforts by various developmental agencies. The major factors responsible for low productivity are: low level of awareness among the farming community about area specific recommended package of practices, less availability of high yielding and resistant varieties seed, lower adoption of recommended plant production and protection technologies. Traditionally farmers are using the seed available with them and most of the time they take advice from fellow farmers. Simultaneously, the availability of quality seed near the vicinity of farmers is also less. Earlier the fenugreek was grown only for fodder purpose and broadcasting was in practice to maintain the high density. Later on farmers started cultivation of fenugreek for grain but with the old method of sowing i.e. broadcasting. Line sowing with recommended crop geometry enhances the yield as the seed is placed at right place leads to proper germination and plant vigour besides it facilitate easy weeding and hoeing. The competition of crop with respect to light, air, water and nutrient is reduced if sown in line. In the initial growth phase fenugreek crop is infected by bacterial wilt and rhizoctonia root rot cause the loss in the rage of 15 to 30%, some times more. These diseases can be cured with proper seed treatment with Trichoderma or bavistin.

Introduction of high yielding varieties can boost the yield levels in the adopted areas. Farm mechanization and appropriate plant protection measure with the recommended package of practices (nutrition, irrigation and intercultural operations etc.) can also play a crucial role. Besides these, effective management of biotic and abiotic stresses at crucial time with the help of available chemicals and organic means is also very important to increase the productivity and production of the crop, which ultimately enhanced the net returns and benefit cost ratio of the growers.

Therefore, to assess the impact of adoption of improved package of practices in fenugreek, village Alniawas located in Nagaur district in the central arid part of Rajasthan state was selected. The selected areas predominantly have sandy soils and cool and dry winter having temp range of 4 to 30 °C. The farmers of this district were away from the adoption of improved agricultural technologies (Garhwal and Arora, 2013) and were practicing the farming with available local varieties and practices for fenugreek. Keeping these facts in view, three high yielding varieties of fenugreek with the scientific interventions like seed treatment and line sowing (with improved seed cum fertilizer drills) through front line demonstrations were tested on fifteen farmer's fields with the following objectives:

1. To exhibit the performance of high yielding fenugreek varieties with scientific interventions at large scale under common package of practices;
2. To compare the yield levels of local (checks) cultivar cultivated using local practices with improved varieties cultivated following mechanized sowing and seed treatment method; and
3. To calculate and compare the economics incurred in following farmers' practice and in adopting scientific interventions (improved varieties, mechanized sowing and seed treatment).

MATERIALS AND METHODS

The present study was carried out by National Research Centre on Seed Spices (NRCSS), Ajmer under national agricultural innovation project (NAIP) Component-2 on "Value chain in major seed spices for domestic and export promotion" during *rabi* season from 2009 to 2010 to 2011 to 2012 (03 years) at farmers' fields of adopted village Alniawas of Nagaur district of Rajasthan having arid climate. About 15 frontline demonstrations per year in about 3.75 ha area on the fields of different farmers were conducted every year. Each demonstration was of 0.25 ha area. The soils of the Alniawas village is sandy in texture with low nitrogen (70 to 20 kg ha^{-1}), low to medium phosphorus (12 to 15 kg ha^{-1}) and medium to high potash (150 to 250 kg ha^{-1}) having organic carbon from 0.26% to 0.45% with low water holding capacity. Three varieties of fenugreek *viz.,* RMt-305, AFg-1 and Afg-2 (Table 2) were tested through front line demonstrations (FLDs) with seed treatment and line sowing and interventions compared with local variety grown with farmer's practices. The materials and inputs required for the study with respect to front line demonstrations (technologies demonstrated) and farmers' practice are given in Table 1.

In demonstration plots, few critical inputs in the form of quality seed, balanced fertilizers, and agro-chemicals for plant protection measures were provided and non-monetary inputs like timely sowing in lines and timely weeding and irrigation were also performed. Whereas, traditional practices were followed in case of local practice or local checks. The farmers who adopted scientific intervention under FLD's were guided in performing field operations like field preparation, sowing, spraying weeding, harvesting etc. through regular trainings and visits. One On-campus and two Off-campus trainings were also organized for the group of beneficiaries under FLD's.

Seed treatment was done with *Trichoderma viride* (6 g kg^{-1}) and Bavistin (2.5 g kg^{-1}) in a closed container and then shade dried for some time before sowing. Line sowing was performed with the help of multi seed spices seed cum fertilizer drills developed by CIAE, Bhopal (RK

Agro Model) and by a local manufacturer of Sanderao town, district Pali, Rajasthan (Sanderao Model). For balanced nutrition, the crop was fed with 25 kg N and 25 kg P_2O_5 ha^{-1} through urea (46% N) and DAP (18 % N and 46% P_2O_5) at the time of sowing. Two sprays of malathion (0.2%) at 15 days interval for the control of aphids (on incidence) and one spray of dinocap (0.1%) for the control of powdery mildew (on initial appearance of symptoms) were given. Growing of locally available seed of fenugreek without seed treatment and fertilization with indiscriminate use of pesticides and fungicides is the farmer's practice prevailing in the area. Sowing was done during third week of October. The demonstrations were conducted to study the gaps between the potential and demonstration yield, extension gap and technology index. Data with

Table 1. Details of existing farmers' practices and scientific interventions for fenugreek cultivation.

S/No.	Farmers' practice	Intervention	Scientific proven technology demonstrated
1.	Locally available seed	Use of improved seed	RMt-305, AFg-1 and AFg-2 as improved varieties 1st from SKNCOA (SKRAU), Jobner (Rajsthan), India and 2nd & 3rd from NRCSS, Ajmer (Rajasthan), India
2.	Broadcasting	Sowing method	Line sowing by 02 tractor operated multi seed spices seed cum fertilizer drills (Sanderao Model- procured from a local manufacturer from Pali district of Rajasthan and R.K Agro Model from Rajkot, Gujarat, India)
3.	No seed treatment	Seed treatment	Seed treatment by Bavistin (2.5 g kg^{-1} seed) and *Trichoderma viride* (6 g kg^{-1} seed)

respect to grain yield from FLD plots and from fields cultivated following local practices adopted by the farmers of the area were collected and evaluated. Potential yield was taken in to consideration on the basis of standard plant population (333330 plants/ha) and average yield per plant (7.5g/ plant) under recommended package of practices with 30 × 10 cm crop geometry (Kakani et al., 2009). Different parameters as suggested by Yadav et al. (2004) was used for gap analysis, and calculating the economics. The details of different parameters and formulae adopted for analysis are as under:

Extension gap = demonstration yield (DY) – Farmers' practice yield (FPY)
Technology gap = Potential yield (PY) – Demonstration yield (DY)

$$\text{Technology index} = \frac{PY - DY}{PY} \times 100$$

Additional cost = Demonstration cost – Farmers' practice cost
Effective gain = Additional returns – Additional cost
Additional returns = Demonstration returns – Farmers' practice return
Incremental B: C Ratio = Additional returns / Additional cost

RESULTS AND DISCUSSION

Grain yield

It is revealed from the performance (Table 3) of the interventions given that significant increase in the yield was recorded in all the FLDs in all the years of the study period. Adoption of improved varieties of fenugreek exhibited 17.80 to 24.86% more yield over the local check, however the mean yield of AFg-1 and AFg-2 was at par. The fluctuation in yield can be explained on the basis of variation in prevailing social, economical and microclimatic conditions of that particular site and year as RMt-305 performed better in first year. Mukharjee (2003) and Jaitawat (2006) has also opined that depending on identification and use of farming situation, specific interventions and microclimatic conditions may have grater implications in enhancing system productivity. Line sowing with the help of seed cum fertilizer drill gave 19.30% (Sanderao Model) to 30.74% (RK Agro Model) higher yield over traditional broadcasting practice. Furrow opener of RK Agro seed drill is relatively wider than Sanderao model, hence placement of seed is at proper depth leads to higher germination percentage and plant vigour, which consequently increased the yield of fenugreek per plant as well as per unit area. Broadcasting leads to higher plant population, gives least facility for weeding and hoeing resulted into more competition for light, air, water and nutrients. Therefore, plant vigour become poor and yield per plant and per unit area remains low. Similarly seed treatment with bavistin exhibited 16.23% and *Trichoderma* 28.33% higher yield over local practice i.e. sowing without seed treatment. Scientific interventions with improved varieties and recommended package of practices were the factors responsible to exploit higher yields over traditional checks/ practices. Further, it is very much clear from the study (Table 4) that, in fenugreek grain yield, significant improvement was recorded with the interventions (improved varieties, seed treatment and line sowing) given in demonstrations as compared to farmers' existing practices. Maximum yield (1649 kg ha^{-1}) under FLDs was recorded in the year 2011 to 2012, which was 24.08% higher than the yield (1329 kg ha^{-1}) obtained under farmers' practice. The increase in grain yield under demonstrations was 23.09 to 24.08 per cent higher than farmers' local practices. On the basis of the above study, it is inferred that an overall yield advantage of 23.51% over farmers' practices was recorded with per hectare yield of 1571 kg ha^{-1} under demonstrations carried out with improved varieties and scientific cultivation practices (Table 4). Similar findings have also been reported by Lal et al. (2013) and Singh et al. (2011).

Gap analysis

Evaluation of findings of the study (Table 4) stated that an extension gap of 284 to 320 kg ha^{-1} was found between demonstrated technology and farmers' practice

Table 2. Brief information about fenugreek varieties.

Name of variety	Brief description	Year of release	Recommended area of cultivation	Potential yield ($kgha^{-1}$)	Maturity duration (days)
AFg-1	Indeterminate type, pure line selection, erect type plant, single pods on nods, medium duration maturity, seeds bold and large, 17-20 seeds per pod.	2005	Rajasthan state of India	2500	137
AFg-2	Indeterminate type, pure line selection, long erect type plants, single or double pods on nods, medium duration maturity, seeds small in size, 16-18 seeds per pod.	2005	Rajasthan state of India	2500	138
RMt-305	Mutant of variety RMT-1, First determinate type, dwarf, early maturing, synchronous maturity, bold size seed, pods in bunches.	2007	Rajasthan state of India	2500	120

Source: Kakani et al. (2009) and personal communication with Dr. Dhirendra Singh, Professor (PBG), SKN College of Agriculture (SKRAU), Jobner, Rajasthan, India and Breeder of RMt-305 fenugreek.

Table 3. Yield performance of different varieties of fenugreek and scientific intervention as compared to local practices during 2009 to 2012.

Interventions		Yield ($kgha^{-1}$)				Yield increase over local check or practice (%)
		2009 to 2010	2010 to 2011	2011 to 2012	Mean	
Improved varieties	RMt-305	1795	1390	1420	1535	17.80
	AFg-1	1600	1650	1620	1623	24.61
	AFg-2	1450	1780	1650	1627	24.87
	Local check	1300	1250	1360	1303	-
Line sowing by seed drill	Sanderao Model	1300	1450	1571	1440	19.30
	RK Agro Model	1412	1590	1733	1578	30.74
	Traditional practice (Broadcasting)	1160	1220	1240	1207	-
Seed treatment	Bavistin (2.5 g kg^{-1})	1400	1460	1694	1518	16.23
	Trichoderma (6g kg^{-1})	1520	1650	1857	1676	28.33
	No seed treatment	1180	1350	1387	1306	-

Table 4. Technological gap analysis of front line demonstrations on fenugreek at farmers' fields.

Year	Number of FLDs	Potential yield ($kgha^{-1}$)	FLD yield ($kgha^{-1}$)	Farmers' practice yield ($kgha^{-1}$)	Yield increase (%)	Extension gap ($kgha^{-1}$)	Technology gap ($kgha^{-1}$)	Technology index (%)
2009 to 2010	15	2500	1497	1213	23.41	284	1003	40.12
2010 to 2011	15	2500	1567	1273	23.09	294	933	37.32
2011 to 2012	15	2500	1649	1329	24.08	320	851	34.04
Overall average	15	2500	1571	1272	23.51	299	929	37.16

Table 5. Economic analysis of technological interventions on fenugreek at farmers' field.

Year	Cost of cash input (Rs.ha^{-1})		Add. Cost in FLD* (Rs.ha^{-1})	Sale price of grain (Rs.ha^{-1})	Total returns (Rs.ha^{-1})		Add. Returns in FLD (Rs.ha^{-1})	Effective gain (Rs.ha^{-1})	INC B:C ratio (IBCR)
	FLD	FP			FLD	FP			
2009-10	3700	2300	1400	30	44910	36390	8520	7120	6.09
2010-11	3700	2300	1400	30	47010	38190	8820	7420	6.30
2011-12	3700	2300	1400	30	49470	39870	9600	8200	6.86
Overall average	3700	2300	1400	30	47130	38160	8970	7570	6.41

FLD: Front line demonstration, FP: Farmers' practice, INC: Incremental; *Cost of seed drill is Rs. 32000.00 and life assumed 10 years. The hiring cost of seed drill is Rs. 300/ha.

and on average basis the extension gap was 299 kg ha^{-1}. The extension gap was highest (320 kg ha^{-1}) during 2011 to 2012 and lowest (284 kg ha^{-1}) during 2009 to 2010. Such gap might be attributed to adoption of improved technology especially 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. The study further exhibited a wide technology gap during different years. It was lowest (851 kg ha^{-1}) during 2011 to 2012 and highest (1003 kg ha^{-1}) during 2009 to 2010. The average technology gap of all the years was 929 kg ha^{-1}. The difference in technology gap in different years is due to better performance of recommended varieties with different interventions and more feasibility of recommended technologies during the course of study.

Similarly, the technology index for all demonstrations in the study was in accordance with technology gap. Higher technology index reflected the inadequate transfer of proven technology to growers and insufficient extension services for transfer of technology. On the basis of three years study, overall 37.16% technical index was recorded, which was reduced from 40.12% (2009 to 2010) to 34.04% (2011 to 2012). Hence, it can be inferred that the awareness and adoption of improved varieties with recommended scientific package of practices have increased during the advancement of study period. These findings are in the conformity of the results of study carried out by Meena and Singh (2011), Meena (2011), Meena and Singh (2013) and Dayanand et al. (2012).

Economic analysis

Variables like seed, fertilizers and pesticides were considered as cash inputs for the demonstrations as well as farmers' practices. Data of economic analysis presented in Table 5 exhibited that, an average additional amount of Rs. 1400/ha was incurred under demonstrations (FLDs) as compared to FP. Economic yield as a function of grain yield and sale price were taken into consideration. Maximum additional returns (Rs. 9600/ha) were obtained in the year 2011 to 2012 due to higher grain yield. The higher additional returns and effective yield obtained under demonstrations could be due to improved variety, scientific proven technology, non-monetary factors, timely operations of crop cultivation and scientific monitoring. The lowest and highest incremental benefit: cost ratio (IBCR) was 6.09 and 6.86 in the year 2009 to 2010 and 2011 to 2012, respectively depends on obtained grain yield. Overall average IBCR was found as 6.41. The results of the study corroborate the findings of front line demonstrations carried out by Lal et al. (2013) on cumin and Singh et al. (2011) on seed spices.

Conclusion

Average yield of the FLDs with improved varieties and scientific technologies was 23.51% higher than the yield under farmers' practice. Front line demonstration program was found to be effective in changing attitude, skill and knowledge by using improved varieties and recommended package of practices of fenugreek cultivation including adoption. It has been verified that yield advantage can be attained by the use of improved varieties, seed treatment, line sowing, application of balanced nutrition with appropriate plant protection measures on farmer' fields. Two varieties of fenugreek (AFg-1 and AFg-2) can be recommended for central arid Rajasthan with technological interventions like line sowing and

seed treatment with *Trichoderma viride* (6 g kg^{-1}) or bavistin (2.5 g kg^{-1}).

Conflict of Interests

The authors have not declared any conflict of interests.

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