

Impact of Drip Irrigation and Fertigation on Residual Soil Nutrient Status, Nutrient Uptake and Nutrient Use Efficiency of Fenugreek under Semi Arid Conditions

C. B. Harisha*, Honnappa Asangi and Ravindra Singh

ICAR-National Research Centre on Seed Spices, Ajmer, Rajasthan, India

*Corresponding Author E-mail: harisha.cb@gmail.com

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ABSTRACT

Fenugreek is important legume seed spice which can grow with less amount of nutrients particularly nitrogen. But fenugreek is moisture loving crop and grows continuously if water is provided. But ideal irrigation and fertigation dose is most crucial for optimizing irrigation and fertilizer level and also achieving better uptake, use efficiency and residual soil nutrient content. Hence experiment was conducted at ICAR-National Research Centre on Seed Spices, Ajmer, Rajasthan during winter season of 2015-16 to find the effect of drip irrigation and fertigation on soil nutrient status and nutrient use efficiency of fenugreek. From the experiment it was found that residual soil nutrient content was significant this influenced the uptake of nutrients by fenugreek crop. Among nutrient uptake potassium is only element shows significant variations and it was highest in drip irrigation at 80 % cumulative pan evaporation (CPE) (64.0 kg/ha) and 100 % CPE (63.4 kg/ha) recorded higher uptake and both are on par. I4F1-drip irrigation at 100% CPE + Fertigation at 50% recommended dose of fertilizers (RDF) is shown highest nitrogen use efficiency (138.6 kg kg⁻¹), phosphorus use efficiency (115.5 kg. kg⁻¹) and potassium use efficiency (153.9 kg.kg⁻¹). This study clearly indicates that 75 % fertigation dose and 80% drip irrigation level is most ideal in terms of residual soil nutrient status. To get better use efficiency application water at higher level and fertigation at lower level is most appropriate.

Key words: Fenugreek, fertigation, uptake, nutrient use efficiency

INTRODUCTION

India is known as land of spices and it is leader of production, consumption and export of seed spices. Among them fenugreek is one of the important seed spices grown in India. Fenugreek (*Trigonella foenum-graecum* L) known as methi, is a multipurpose crop in which leaf and seed are used as leafy

vegetable, seed spices and condiments⁶. Leaves are used for garnishing, flavouring dishes and also it is having lot of medicinal properties particularly for diabetes. Crop is mainly grown in semi arid regions of India including Rajasthan, Gujarat, Madhya Pradesh, Karnataka, Telangana and Tamil Nadu etc in winter season for seed purpose.

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Fenugreek is legume crop and can fix nitrogen in root nodule and hence demand for nitrogen by this crop is very less. The productivity of this crop is controlled by many factors, of which mineral nutrition and irrigation are most important. It is grown in northern India under limited irrigation condition and almost without fertilizers.

In recent days agriculture human availability of labour, improper application of fertilizers and effective use of applied nutrients is important concern. In arid and semi arid regions where water is limited and soils are poor sandy or sandy loam soil type makes more number of irrigation and fertilizers applications necessary in crop production. Higher soil nutrient holding ability and timely supply to crop is very important in order to achieve higher yields. But in actual condition it is not happening. Soils are depleting faster due to non judicious use of fertilizers particularly nitrogen fertilizers. Drip irrigation and fertigation is most suited for semi-arid and arid areas². Drip irrigation system has the potential for improving two of the most common contributing factors to N leaching *i.e.* over fertilization and over irrigation⁵. To overcome these difficulties adopting drip irrigation and fertigation is highly necessary among the farmers so that can save labour, water and even fertilizers also. Fertigation is one important precision farming technique which can give better nutrient use efficiency as compared to surface irrigation method¹. Application of nutrients untimely, following inappropriate method of application leads to severe loss of nutrients by leaching and fixation⁴.

Looking to all the difficulties facing by surface irrigation and sprinkler method use

of most ideal method of irrigation which facilitates fertigation and better nutrient use efficiency is very much needed today. Under this situation there is a need of standardizing drip irrigation and fertigation technique for fenugreek which is suitable for sandy loam soils of semi arid regions is most required. To get maximum production of fenugreek it is highly necessary to assess the nutrient required by the crop and nutrient uptake by entire crop during cropping season. It also necessary to find the soil nutrient status and fertilizer use efficiency under drip irrigation and fertigation conditions. Hence, an experiment was conducted to study the effect of drip irrigation and fertigation levels on soil, plant nutrient status after harvest and nutrient uptake by fenugreek.

MATERIALS AND METHODS

The field experiment was conducted during winter season of 2015-16 at Research farm of ICAR-National Research Centre on Seed Spices, Ajmer, Rajasthan. The soil of experimental plot was sandy loam in nature having pH 7.6, EC 0.3 dSm⁻¹ and available N 148 kg ha⁻¹, P₂O₅ 16.5 kg ha⁻¹ and K₂O 325 kg ha⁻¹. Fenugreek variety Afg-1 (Ajmer fenugreek-1) was used in the trial. In this trial four drip irrigation levels (I₁- 40 % CPE, I₂- 60 % CPE, I₃ - 80 % CPE and I₄-100% CPE) and three fertigation levels (F₁ - 50 % RDF, F₂ - 75 % RDF and F₃ - 100 % RDF). Recommended dose of fertilizer for fenugreek is 40:30:20 kg N, P₂O₅, K₂O per hectare. The experiment was laid out in split plot design with three replications. Drip irrigation lateral pipes with inline drippers spaced at 30 cm with discharge of dripper at the rate of 2.3 litre per hour were used in the trial. Irrigation pressure was

maintained at 2.5 g/cc to have adequate discharge from the drippers. Irrigation was given once in four days and eight fertigation was given during entire cropping period starting from fifteen days after germination of crop at eight days interval. Crop was raised on broad raised beds made with tractor drawn bed maker cum seed drill. Raised beds of 1.4m x 0.15m x 40m are prepared and seeds were sown in lines with a drill spacing of 25 cm between the rows. Plant to plant distance was maintained to 15cm by thinning after thirty days of sowing. Pan evaporation data was recorded from USA type open pan evaporymeter daily at 8.30 hrs and 14.30hrs. Quantity of irrigation water was calculated as per the discharge rate of each dripper in a line

and total drippers in each bed. Fertigation was given by water soluble fertilizers such as urea phosphate (16:44:0 N, P₂O₅, K₂O respectively), sulphate of potash and urea by ventury. Plant samples were collected at the maturity stage (130 DAS) and air dried to estimate the biomass and the same samples were used for plant nutrient analysis. Soil samples were collected at 15cm depth after the harvest of crop and subjected to N, P₂O₅ and K₂O analysis. The data collected on growth and yield parameters were subjected to analysis of variance (ANOVA and LSD @ 0.05) of Split plot design. Uptakes of major nutrients are calculated using following formula

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%)} \times \text{dry matter production (kg ha}^{-1}\text{)}}{100}$$

RESULTS AND DISCUSSION

Results obtained from the experiment reveals significant variations in soil, plant and uptake pattern of major nutrients by fenugreek as influenced by drip irrigation levels and fertigation doses. The results on residual soil nutrient status, uptake of nutrients and nutrient use efficiency were presented in table 1, 2 and 3 respectively.

Soil residual nutrient status

Results on soil nutrient status after harvest of crop (table 1) indicate that there are significant differences. Soil residual nitrogen was highest in I₄- drip irrigation @ 100 % CPE with all fertigation levels (130.4 kg ha⁻¹). But fertigation as such did not show any significant results. The nitrogen content is varying widely as fenugreek prefers less applied nitrogen from external sources. It also shows that application of nitrogen at 100%

dose leads to reduction in residual N status. Hence it is ideal to apply fertigation of N at 75 percent. Residual P was not influenced by fertigation levels but it was found that applying fertigation at 75 percent is ideal in terms of having higher residual status. Interestingly soil potassium was significantly varied by fertigation as well as drip irrigation. Highest residual potassium was found in I4F3 (597.4 kg ha⁻¹) followed by I1F3 (469.6 kg ha⁻¹). This clearly indicates that higher irrigation causes the upward movement of potassium ion leading to higher residue and in the same way less irrigation makes the fertilizer solution to remain on the surface itself. It shows that residual soil nitrogen content reduced and phosphorus content was increased after the harvest of fenugreek crop as compared to initial soil nutrient status.

Nutrient uptake by fenugreek crop

Results on nutrient uptake by fenugreek are shown in Table 2. It indicates that nitrogen and phosphorus uptake was not influenced either by fertigation or by drip irrigation. Only potassium showed significant differences in uptake as influenced by drip irrigation and also fertigation. Even then nitrogen being important nutrient in crop production, results obtained shows that drip irrigation at 80% CPE (44.2 kg/ha) is ideal and resulted higher N uptake and reduced the uptake as irrigation level increased to 100% CPE (34.3 kg/ha). In case of fertigation also increasing the dose of fertilizers reduces the uptake of nitrogen and it was highest in fertigation at 50% RDF (38.1 kg/ha). This is mainly attributed to lower soil residual nitrogen status corresponds to higher uptake of nitrogen by fenugreek. Similarly in case of potassium uptake drip irrigation at 80 % CPE (64.0 kg/ha) and 100 % CPE (63.4 kg/ha) recorded higher uptake and both are on par. In case of fertigation levels there was clear trend of increasing potassium uptake as increase in fertigation dose. Highest average potassium uptake (65 kg/ha) was recorded from 100 percent fertigation dose (F3). This clearly indicates that potassium is important element for fenugreek as compared to nitrogen and phosphorus. The higher uptake of potassium in drip irrigation and fertigation may be due to the regular irrigation and supply of potassium fertilizer to crop and also may be due to the higher amount of nutrients in the plant tissue. This was also reported that due to alternate wetting and drying might have improved the soil aeration and thus root activity to improve the uptake of nutrients in drip irrigation system. Increased root dry matter and root volume might have exploited more soil volume for nutrient absorption⁸. In

tomato it also reported that increased potassium level in fertigation increased the potassium uptake⁷.

Nutrient use efficiency of fenugreek

Nitrogen, phosphorus and potassium use efficiency (kg grain/kg nutrient applied) was calculated and results are presented in table 3. The results on nitrogen use efficiency are shows significant differences with drip irrigation and fertigation levels. In case of drip irrigation levels higher nitrogen use efficiency was observed in I4-drip irrigation @ 100% CPE (102.3 kg. kg⁻¹) and it was decreased with reducing the irrigation levels. In case of fertigation levels higher N use efficiency was noticed in F1-fertigation at 50% RDF (123.2 kg.kg⁻¹) and its efficiency was decreased at increased application rate. Among the combinations of irrigation and fertigation I4F1-drip irrigation at 100% CPE + Fertigation at 50% RDF is shown highest nitrogen use efficiency (138.6 kg kg⁻¹). Similar trend was observed in case of phosphorus and potassium use efficacy. P and K use efficiency was increased with increase of drip irrigation levels and use efficiency decreased with increased levels of fertigation. This is mainly attributed to better availability of moisture leads to better solubility of nutrients and better use. Similarly higher dose of fertilizers leads to more loss than lower dose. This is the fact that contributed the low use efficiency of all the nutrients at higher fertigation levels. It is reported that apparent N recovery percentage was higher at the lowest N level and decreased with increasing N levels in aerobic rice³. Nutrient use efficiency in fertigation increases as a result of controlled and regular application of fertilizer.

Table 1: Effect of drip irrigation and fertigation levels on residual soil nutrient status in fenugreek

Treatments	Soil N (kg/ha)				Soil P ₂ O ₅ (kg/ha)				Soil K ₂ O (kg/ha)			
	F1-50%	F2-75%	F3-100%	Mean I	F1-50%	F2-75%	F3-100%	Mean I	F1-50%	F2-75%	F3-100%	Mean I
I ₁ -40% PE	109.1	111.5	121.2	114.9	23.1	63.6	42.2	42.9	305.9	376.7	469.6	384.1
I ₂ -60% PE	124.2	128.3	113.7	122.1	50.1	26.3	33.2	36.5	391.7	445.3	347.5	374.8
I ₃ -80% PE	124.5	125.0	119.6	123.6	49.2	48.0	54.7	50.6	295.1	348.7	354.8	332.8
I ₄ -100% PE	130.4	130.4	130.4	130.4	30.6	25.5	20.8	25.6	389.3	409.2	597.4	465.3
Mean F	122.1	124.6	121.2		38.2	40.8	37.7		345.5	395.0	442.3	
factors	CD 5%	S.Em ±			CD 5%	S.Em ±			CD 5%	S.Em ±		
Factor I	8.10	2.29			12.2	3.46			92.9	26.3		
Factor F	NS	1.12			NS	4.76			68.7	22.7		
F X I	7.51	3.97			NS	6.00			145.1	45.6		
I X F	9.80	2.94			NS	8.51			145.3	45.5		

NS- Non significant

Table 2: Effect of drip irrigation and fertigation levels on nutrient uptake by fenugreek crop

Treatments	N uptake (kg/ha)				P ₂ O ₅ uptake (kg/ha)				K ₂ O uptake (kg/ha)			
	F1-50%	F2-75%	F3-100%	Mean I	F1-50%	F2-75%	F3-100%	Mean I	F1-50%	F2-75%	F3-100%	Mean I
I ₁ -40% PE	33.4	26.9	34.3	31.5	2.06	2.13	2.46	2.22	46.8	48.9	54.3	50.0
I ₂ -60% PE	39.2	37.7	21.2	32.7	2.36	2.30	2.80	2.48	46.2	52.9	65.2	54.8
I ₃ -80% PE	41.7	42.6	48.2	44.2	2.90	2.66	2.73	2.76	58.1	65.4	68.6	64.0
I ₄ -100% PE	38.3	35.5	29.2	34.3	2.63	3.23	2.56	2.81	53.8	64.4	71.9	63.4
Mean F	38.1	35.6	33.2		2.49	2.58	2.64		51.2	57.9	65.0	
factors	CD 5%	S.Em ±			CD 5%	S.Em ±			CD 5%	S.Em ±		
Factor I	NS	2.68			NS	0.16			8.45	2.39		
Factor F	NS	2.81			NS	0.098			5.02	1.66		
F X I	NS	4.64			NS	0.27			NS	4.14		
I X F	NS	5.32			NS	0.22			NS	3.61		

NS- Non significant

Table 3: Effect of drip irrigation and fertigation levels on nutrient use efficiency of fenugreek

Treatments	N use efficiency (kg kg ⁻¹ N)				P use efficiency (kg kg ⁻¹ P)				K use efficiency (kg kg ⁻¹ K)			
	F1-50%	F2-75%	F3-100%	Mean I	F1-50%	F2-75%	F3-100%	Mean I	F1-50%	F2-75%	F3-100%	Mean I
I ₁ -40% PE	109.5	74.7	59.4	81.84	91.2	62.3	49.4	67.6	136.9	93.4	74.2	101.5
I ₂ -60% PE	116.3	78.0	60.4	84.9	96.9	65	50.4	70.7	145.4	97.5	75.6	106.1
I ₃ -80% PE	128.3	89.8	71.7	96.6	106.9	74.8	59.8	80.5	160.3	112.2	89.7	120.7
I ₄ -100% PE	138.6	95.7	72.6	102.3	115.5	79.8	60.5	85.2	173.2	119.7	90.7	127.9
Mean F	123.2	84.5	66.0		102.6	70.4	55.0		153.9	105.7	82.5	
factors	CD 5%	S.Em ±			CD 5%	S.Em ±			CD 5%	S.Em ±		
Factor I	14.7	4.17			12.2	3.47			18.4	5.21		
Factor F	12.5	4.14			10.43	3.45			15.6	5.17		
F X I	NS	7.22			NS	6.01			NS	9.03		
I X F	NS	7.94			NS	6.61			NS	9.93		

NS- Non significant

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