Research Article

Residual Soil Nutrient Status, Nutrient Uptake and Use Efficiency of Fenugreek as Influenced by Drip Irrigation and Fertigation on Under Semi-Arid Conditions

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Abstract

Fenugreek is major dual purpose crop, which is cultivated in semi-arid conditions in rabi season for seed and mostly throughout the year for herb. Since the crop legume in nature can fix nitrogen in root nodules but crop is highly susceptible for moisture stress. Therefore, filed experiment was conducted at ICAR-National Research Centre on Seed Spices, Ajmer, Rajasthan during winter season of 2016-17 to find the effect of drip irrigation and fertigation levels on residual soil nutrient status, nutrient uptake and nutrient use efficiency of fenugreek. From the experiment it was found that residual soil nutrient content was significant and highest residual nitrogen (105 kg/ha), phosphorus (5.9 kg/ha) and potassium (62 kg/ha) was found in I_3 (drip irrigation 75% CPE) which is on par with drip irrigation 50% CPE but in case of drip fertigation, highest nitrogen (92.8 kg/ha) and available potassium (57.2 kg/ha) was found in F_4 (drip fertigation 100% RDF). Similarly, nitrogen use efficiency (175.12 kg/ha), phosphorus use efficiency (166.05 kg/ha) and potassium use efficiency (213.52 kg/ha) was highest in drip irrigation at 75% CPE (I_3). All these parameters are on par with drip irrigation 50% CPE. Similarly, fertigation at 25% RDF resulted higher nitrogen use efficiency (266.24 kg/ha), phosphorus use efficiency (252.35 kg/ha) and potassium use efficiency (327.66 kg/ha) and all are at par with Fertigation at 50% RDF. This study clearly indicates that 50 % fertigation dose and 75 % 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.

Keywords: Fenugreek, fertigation, uptake, nutrient use efficiency

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Introduction

Fenugreek (*Trigonella foenum-graecum* L), is a leguminaceae crop which is known as methi, is a multipurpose crop in which leaf and seed are used as leafy vegetable, seed spices and condiments. It is an important major seed spice crop mainly grown in arid and semi arid regions of India. In India, the major fenugreek growing states are Rajasthan, Gujarat, Madhya Pradesh, Tamil Nadu, Uttar Pradesh and Punjab. More than 80 per cent area and production of the country is contributed by Rajasthan state alone. Fenugreek is legume crop and can fix nitrogen in root nodule and hence demand for nitrogen by this crop is very less. It is also reported that fenugreek is sensitive to water stress particularly deficit irrigation [1]. The problem of high salinity has been observed in the arid and semi-arid regions of Rajasthan. The only sources of water in these regions are highly saline ground water. A significant part of the applied water is lost in conveyance, application, run-off and evaporation resulting in very low water use efficiency. Normal surface irrigation technique do not meet the requirement at the root zone for longer period due to the excessive percolation and other losses, which results in problem of water logging, soil salinity and even drought like conditions. In fenugreek crop irrigation water is the important natural resources which are pre requisite for higher productivity in semi arid conditions since this crop is susceptible to moisture stress [2]. This necessitates the implementation of improved systems of irrigation, which irrigates the plants rather than the field and results in productive use of water. Therefore, efforts are now directed to harness available quantity of water and put them to efficient use to realize higher productivity per drop.

Drip irrigation has emerged as an appropriate water saving technique especially for low spaced high value crops in water scarcity of seed spice growing area. Water consumption due to drip irrigation method is less as compared to the surface method of irrigation and it varies from 30 to 70 percent for different crops [3]. In case of nutrient management untimely application of nutrients by inappropriate method of application leads to severe loss of nutrients

by leaching and fixation [4]. Fertigation helps in obtaining higher productivity and quality of the produce, resource use efficiency, environmental safety, effective crop management. To get maximum production of fenugreek it is highly necessary to assess the nutrient required by the fenugreek and nutrient uptake by entire crop during cropping season under drip irrigation and fertigation conditions. Apart from this residual soil nutrient status and nutrient use efficiency plays major role in assessing crop productivity. Hence, an experiment was conducted to study the effect of drip irrigation and fertigation levels on residual 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 8.1, EC 0.12 dSm^{-1} and available N 112.1 kg/ha, P_2O_5 23.5 kg/ha and K_2O 271.0 kg/ha. Fenugreek variety AFg-1 (Ajmer fenugreek) was used in the study. The field experiment was laid out in a split plot design and replicated three times. In this trial three drip irrigation levels (I_1 - 25 % CPE, I_2- 50 % CPE and I_3 - 75 % CPE) and four fertigation levels (F_1 - 25 % RDF, F_2 - 50 % RDF, F_3 – 75% RDF and F_4 - 100 % RDF) were studied. Recommended dose of fertilizer for fenugreek is 25:30:20 kg N, P_2O_5, K_2O per hectare was used as 100% RDF. Crop was irrigated by drip irrigation system of Netafim make having laterals of 16 liter discharge and they are placed at 50 cm apart. Each inline dripper in a lateral is spaced at 30 cm distance. 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. Total 26 drip irrigations were gave during entire crop period as per the requirement of crop time to time.

Crop was raised on broad raised beds make with tractor drawn bed maker cum seed drill. Raised beds of 1.4m x 44m 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 10 cm by thinning after fifteen days of sowing. Pan evaporation data was recorded from USA type open pan evapometer 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, P_2O_5, K_2O respectively), sulphate of potash and urea by ventury. Plant samples were collected at the maturity stage 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, P_2O_5 and K_2O analysis. Uptakes of major nutrients are calculated using following formula.

$$Nutrient\ uptake\ \left(\frac{kg}{ha}\right) = \frac{\text{nutrient content in plant(\%) x dry matter production } \left(\frac{\text{kg}}{\text{ha}}\right)}{100}$$

Nutrient use efficiency in fenugreek was calculated by using following formula

$$Nutrient\ use\ efficiency\ \left(\frac{kg}{ha}\right) = \frac{\text{Seed yield } \left(\frac{\text{kg}}{\text{ha}}\right)}{\text{Nutrient applied } \left(\frac{\text{kg}}{\text{ha}}\right)}$$

The data recorded on soil nutrient status, nutrient uptake and use efficiency was subjected to analysis of variance (ANOVA and LSD @ 0.05) using Split plot design.

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 **Tables 1, 2** and **Figure 1**.

Soil residual nutrient status

Results on soil nutrient status after harvest of crop (table 1) indicate that there are significant differences. In case of drip irrigation soil residual nitrogen was highest (129.92 kg/ha) in I_3 (drip irrigation 75% CPE). The lowest nitrogen content in soil (116.87 kg/ha) was found in I_1 (drip irrigation 25% CPE). Similarly, residual P_2O_5 and K_2O was

significantly highest in (24.1 and 317.5 kg/ha respectively) treatment I_3 (irrigation at 75% CPE). This clearly indicates that application of higher amount of irrigation leads to better availability of nutrients by maintaining adequate soil moisture in the root zone. These results are in confined with [2] in fenugreek. In case fertigation residual soil nitrogen was highest (126.2 kg/ha) in F_4 (100% RDF) which is at par with drip irrigation 75% and 50% RDF. Whereas, residual P_2O_5 was found highest in I_3 (50% CPE) but available K_2O content was influenced by the fertigation levels. This indicates that application of nitrogen in any dose is not utilized by the fenugreek. This may be due to legume nature of crop which can fix nitrogen in root nodules and application of 50% of nutrients is sufficient for fenugreek when applied through irrigation water. The availability of potassium content was higher than initial status in soil irrespective of fertigation levels. Available K_2O content was more in the surface layer due to entrance of K ions on soil exchange complex resulting in very small movement to deeper layer. Similarly results were found by [4] in fenugreek, [5] in paddy.

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

Treatment	**Soil N kg/ha**				**Soil P kg/ha**				**Soil K kg/ha**			
	I_1 – 25%	**I_2 – 50%**	**I_3 – 75%**	**Mean F**	**I_1 – 25%**	**I_2 – 50%**	**I_3 – 75%**	**Mean F**	**I_1 – 25%**	**I_2 – 50%**	**I_3 – 75%**	**Mean F**
F_1 – 25%	106.23	116.66	123.76	115.5	16.23	17.96	17.96	17.3	288.96	276.06	248.33	271.12
F_2 – 50%	119.16	117.10	132.56	122.9	20.70	18.96	24.13	21.2	283.56	305.40	366.26	333.41
F_3 – 75%	120.0	123.56	130.43	124.6	23.06	22.40	26.13	23.8	247.00	287.93	307.70	280.87
F_4 – 100%	122.10	123.76	132.93	126.2	20.53	21.36	28.40	23.4	262.26	268.46	347.83	292.85
Mean I	116.87	120.27	129.92		20.13	20.17	24.15		270.45	295.71	317.53	
Factor	**CD 5%**	**S.Em ±**			**CD 5%**	**S.Em ±**			**CD 5%**	**S.Em ±**		
Factor F	7.575	2.530			2.506	0.837			20.742	6.927		
Factor I	9.743	2.417			2.491	0.618			NS	13.367		
F x I	NS	4.833			NS	1.236			43.686	26.734		
I x F	NS	4.499			NS	1.399			61.463	16.931		

NS- non significant, * significant at 5%, CD-Critical difference, SE.m- standard error of mean
CPE-Cumulative pan evaporation, RDF-Recommended dose of fertilizers

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

Treatment	**N uptake kg/ha**				**P uptake kg/ha**				**K uptake kg/ha**			
	I_1 – 25%	**I_2 – 50%**	**I_3 – 75%**	**Mean F**	**I_1 – 25%**	**I_2 – 50%**	**I_3 – 75%**	**Mean F**	**I_1 – 25%**	**I_2 – 50%**	**I_3 – 75%**	**Mean F**
F_1 – 25%	50.63	76.53	75.16	67.44	2.53	4.36	4.53	3.81	26.66	49.56	43.50	39.91
F_2 – 50%	53.86	83.26	112.36	83.16	1.90	4.86	6.53	4.43	27.70	52.66	71.70	50.68
F_3 – 75%	60.03	101.20	116.36	92.53	2.70	4.70	6.96	4.78	36.16	55.20	68.13	53.16
F_4 – 100%	64.13	98.06	116.26	92.82	3.23	4.76	5.70	4.56	44.13	62.86	64.86	57.28
Mean I	57.16	89.76	105.04		2.59	4.67	5.93		33.66	55.07	62.05	
Factor	**CD 5%**	**S.Em ±**			**CD 5%**	**S.Em ±**			**CD 5%**	**S.Em ±**		
Factor F	13.77	4.602			NS	0.255			8.345	2.787		
Factor I	16.43	4.077			0.991	0.246			12.493	0.399		
F x I	NS	8.153			NS	0.491			NS	6.197		
I x F	NS	8.017			NS	0.455			NS	5.204		

NS- non significant, * significant at 5%, CD-Critical difference, SE.m- standard error of mean
CPE-Cumulative pan evaporation, RDF-Recommended dose of fertilizers

Nutrient uptake by fenugreek crop

Results on nutrient uptake by fenugreek crop are shown in Table 2. Drip irrigation resulted significantly higher nitrogen, phosphorus and potassium uptake by fenugreek (105 kg/ha), (5.9 kg/ha) and (62.0 kg/ha) in I_3 (drip irrigation at 75% CPE) which was on par with I_2 (drip irrigation at 50% CPE) (89.7, 4.6 and 55 kg N, P_2O_5 and K_2O ha respectively). Irrigation levels had significant effect on nutrient uptake which attributed due to higher biomass and nutrient content in the plant sample. Irrigation is important practice which influences the availability of nutrients and

effective uptake by plant root system. Frequent application by irrigation water made the fenugreek crop to remove better amount of nutrients, but irrigation at 50% CPE is found optimum where it is at par with 75% CPE.

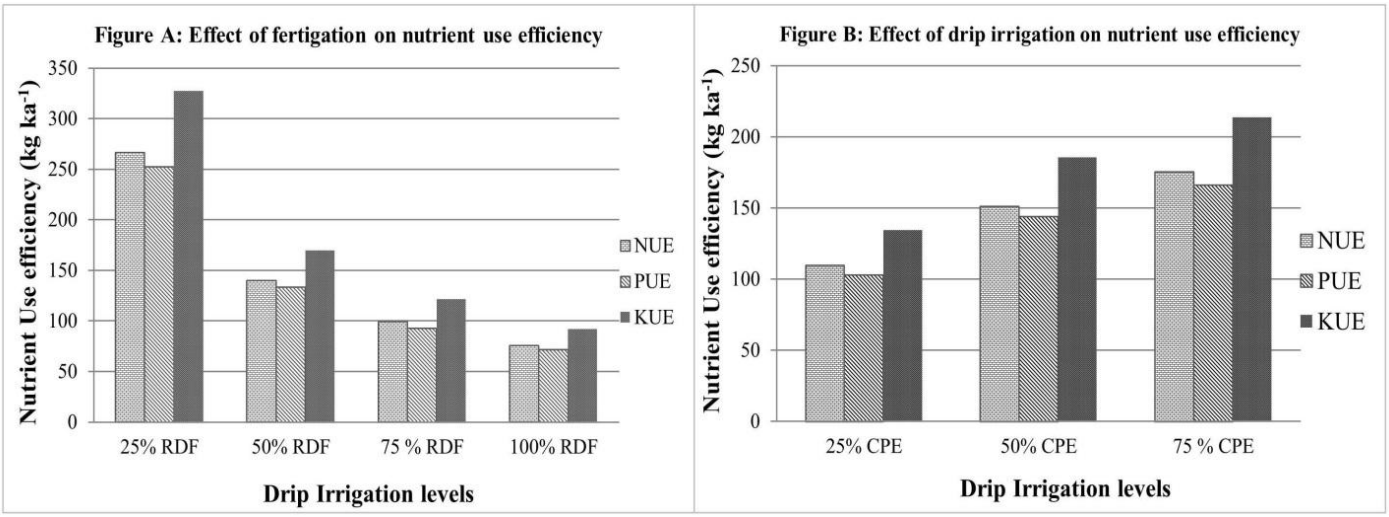

Figure 1 Effect of Drip irrigation and fertigation levels on nitrogen, phosphorus and potassium use efficiency in fenugreek

In case of fertigation levels significantly higher nitrogen and potassium uptake by fenugreek (92.8 kg/ha) and (57.2 kg/ha) was recorded in treatment F_4 (drip fertigation 100% RDF) which is at par with F3 (fertigation @ 75% RDF) and F2 (fertigation @ 50% RDF). Fenugreek crop nutrient demand is very less and also being a legume crop it can fix nitrogen in its root nodules make the crop to develop roots profusely and healthy. It may be due to the fact that under drip fertigation, nutrients were applied in right time and at root zone leads effective utilization which resulted in better and at par results with lower levels of fertilizer application as compared to 100% RDF. Similarly result found by [6] in cluster bean, [7] in fennel and [3] in fenugreek.

Nutrient use efficiency of fenugreek

Nitrogen, phosphorus and potassium use efficiency (kg grain/kg nutrient applied) was calculated and results are presented in figure 1 (A and B). 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 fenugreek (175.1 kg/ha) in I_3 (drip irrigation at 75% CPE) and it was decreased with reducing the irrigation levels. In case of fertigation levels higher N use efficiency was noticed in F_1 (drip fertigation at 25% RDF) (266.2 kg/h) which is on par with F_2 (drip fertigation at 50% RDF) (139.9 kg/ha) and it was decreased with increasing the fertigation levels. N, P and K use efficiency was increased with increase of drip irrigation levels and use efficiency decreased with increased levels of fertigation. In general plants absorbs required amount of nutrients for its regular metabolic processes. If we apply excess this may leads to non-utilization or losses by various means. It is true in this study also. It also found that soil residual nitrogen status was highest in higher fertigation level and it indicates that applied nitrogen was utilized by the fenugreek crop. The reason might be that the crop uptake increases as the dosage increases and become steady or decline after a critical limit. In drip and fertigation treatments, the soil remains moist because of regular and sufficient irrigation on the basis of evapo-transpiration demand of the crop and also right quantity of water and nutrient is applied in the vicinity of root zone which helps in maintaining optimum water potential in plant system favoring photosynthesis, which consequently resulted in better nutrient use efficiency of the fenugreek. Resulted in greater Nitrogen, phosphorus and potassium use efficiencies because of use of small quantity of nutrient in better way as compared to higher doses where most of the nutrients remain unused or wasted. Similar findings were [7] in fenugreek.

Conclusion

Fenugreek is nitrogen fixing legume crop which requires less nitrogen from external source. Hence application of 50 % of recommended dose of nutrients by drip irrigation at rate of 75% cumulative pan evaporation is optimum to achieve better nutrient use efficiency and uptake of nutrients. As irrigation level increases nutrient use efficiency also increases and it is due to better availability of moisture in the root zone. But application of higher nutrients by

fertigation reduces the nutrient use efficiency. Hence timely and proper method application is most important parameter to be considered while irrigating the crop and nutrient management. This helps in better assimilation and photosynthetic rate. From this 50% of nutrients and 25% of irrigation water can be saved.

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