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Effect of irrigation regimes on moisture extraction pattern, evapotranspiration and yield of fenugreek (*Trigonella foenum-graecum* L.)

S Datta & R Chatterjee

Department of Spices and Plantation Crops
Bidhan Chandra Krishi Viswavidyalaya
Mohanpur, Nadia – 741252, West Bengal, India.
E-mail: suchanddatta@rediffmail.com

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Abstract

A field experiment was undertaken at Nadia (West Bengal) to study the effect of irrigation on moisture extraction pattern, evapotranspiration and yield of fenugreek (*Trigonella foenum-graecum*). The study revealed that irrigation influenced the moisture extraction pattern of the crop and higher amount of moisture was extracted from surface layer irrespective of irrigation treatment and depletion of soil moisture increased with increasing level of irrigation. Seed yield and water use efficiency were influenced by different levels of irrigation. The highest water use efficiency was recorded in no irrigation and it was lowest in higher level of irrigation at IW/CPE at 1.0. The highest seed yield, gross return, net return and benefit : cost ratio were recorded at IW/CPE ratio 1.0. Scheduling of irrigation at IW/CPE ratio 1.0 was most beneficial followed by IW/CPE ratio 0.8 and irrigation at branching + flowering + seed development stages with respect to yield and return.

Keywords: Evapotranspiration, fenugreek, irrigation, *Trigonella foenum-graecum,* water use efficiency, yield.

Fenugreek (*Trigonella foenum-graecum* L.) is mostly grown as an irrigated crop during *rabi* (winter) and *kharif* (rainy) seasons in South India and as *rabi* crop in North India (Ravindran *et al.* 2001). In West Bengal fenugreek is grown to a limited extent as a rainfed crop leading to low productivity. But there is immense potential to increase the productivity of the crop by growing the crop under irrigated condition. The present experiment was carried out to study the moisture extraction pattern and evapotranspiration under different irrigation levels and to find out appropriate irrigation schedules to increase the productivity of fenugreek.

The field experiment was undertaken at Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Nadia (West Bengal) during winter season of 2000–2001. The experimental soil was sandy clay loam in texture, having 6.7 pH, 0.63% organic carbon, 0.07% total nitrogen, 45 kg P_2O_5 ha^{-1} and 162 kg K_2O ha^{-1}. The experiment was laid out in a randomized block design with three replications. The treatments comprised of seven irrigation levels (T_1=No irrigation, T_2=Irrigation at branching stage, T_3=Irrigation at branching + flowering stages, T_4=Irrigation at branching + flowering + seed development stages, T_5=Irrigation at 0.6 IW/CPE ratio,

T_6=Irrigation at 0.8 IW/CPE ratio and T_7=Irrigation at 1.0 IW/CPE ratio). One common pre-sowing irrigation of 5 cm was given uniformly irrespective of treatment for better seed germination and crop establishment. The sowing of Rajendra Kranti variety of fenugreek was done during last week of November 2000 in plots of 4.5 m x 3.0 m with a spacing of 30 cm x 10 cm. Farmyard manure (20 t ha^{-1}) and inorganic N (60 kg ha^{-1}), P_2O_5 (40 kg ha^{-1}) and K_2O (30 kg ha^{-1}) fertilizers were applied. Other cultural practices were carried out as and when required.

The depth of irrigation at each irrigation was 5 cm. Irrigation for growth stage treatments were applied at pre-determined stages. In IW/CPE ratio treatment, irrigation was applied when cumulative pan evaporation (USWB Class A Pan) reached the required value. Soil moisture was determined by gravimetric method taking data at every fortnight and also before and 48 h after irrigation. Profile depletion was calculated by adding the value of depletion of available soil moisture in 15 days cycle to a depth of 60 cm (0–15 cm, 15–30 cm, 30–45 cm and 45–60 cm). The value of consumptive use was same with profile depletion because during growing periods, no rainfall occurred. Crop evapotranspiration was also calculated on the basis of profile depletion considering the fact that consumptive use is more or less equal to crop evapotranspiration. Water use efficiency was calculated by dividing the seed yield with the respective value of consumptive use. Statistical analysis of data was done as per method suggested by Gomez & Gomez (1984). The cost of production and gross return were estimated on the basis of price fixed by Government of West Bengal to work out the economics of fenugreek cultivation.

Moisture extraction pattern

Moisture extraction was maximum in 0–15 cm soil depth irrespective of irrigation and decreased with soil depth (Fig. 1). Higher amount of moisture was extracted from the top soil layers and about 54.48% soil moisture was extracted from the top 30 cm of soil depth under no irrigation treatment and in case of IW/CPE ratio 1.0 (highest level of irrigation) treatment more than 65% soil moisture was extracted at the same depth. This indicated that irrigation levels had prominent effect on soil moisture extraction pattern. Soil moisture extraction from 15 cm soil depth increased with increasing irrigation level. The higher amount of water uptake from surface layer might be due to increased surface evaporation, shallow root density and higher water uptake due to availability of irrigation water. These findings also corroborate with the findings of Haiti *et al.* (2001) in case of wheat. In no irrigation and comparatively lower level of irrigation treatments, moisture extraction was higher from deeper (30–60 cm) soil layer. In this condition moisture stress compelled the roots to go into deeper soil layer for utilization of water for their proper growth and development.

Evapotranspiration

Crop evapotranspiration increased steadily from germination stage onwards, in all the treatments and reached its peak between 60 and 90 days after sowing and thereafter decreased gradually and marked decrease was recorded at maturity (Fig. 2). Irrigation level had considerable influence on crop evapotranspiration. Evapotranspiration throughout the growth period was higher for irrigated condition (T_2 to T_7) as compared to no irrigation treatment. Evapotranspiration reached its peak earlier (between 60 and 75 days after sowing) in T_1, T_2 and T_3 treatments. Higher level of irrigation increased evapotranspiration because under such situation, it stimulated better growth of both above ground and root biomass. This resulted in a higher transpiration requirement of the crop and also supplied higher amount of soil moisture to the plants through root proliferation (Corbels *et al.*1998).

Consumptive use and water use efficiency

Irrigation level had a marked influence on number of irrigations, crop duration, con-

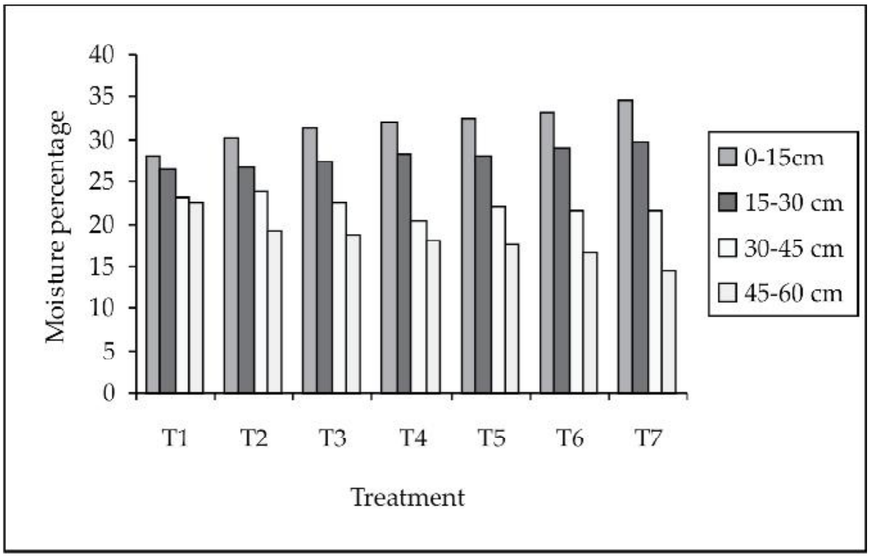

Fig. 1. Moisture extraction pattern of fenugreek under different irrigation regimes.
T_1=No irrigation; T_2=Irrigation at branching stage; T_3=Irrigation at branching + flowering stages; T_4=Irrigation at branching + flowering + seed development stages; T_5=Irrigation at 0.6 IW/CPE ratio; T_6=Irrigation at 0.80 IW/CPE ratio; T_7=Irrigation at 1.0 IW/CPE ratio.

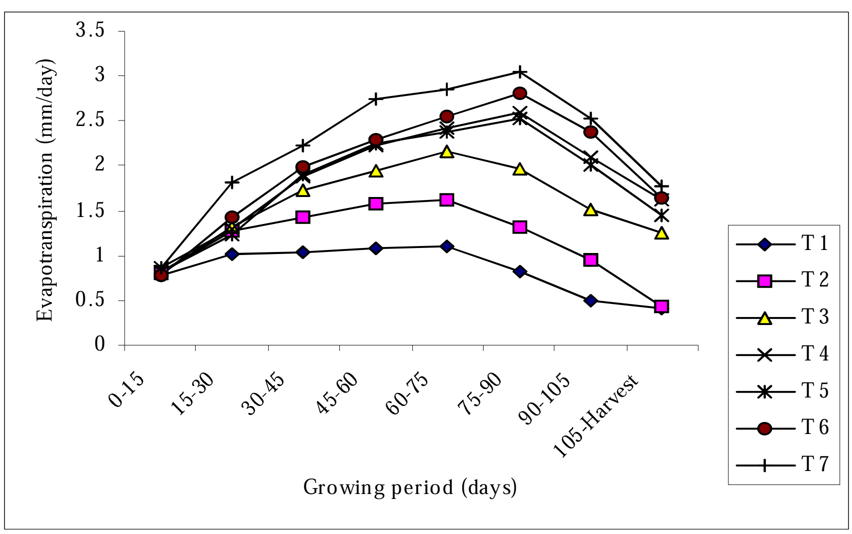

Fig. 2. Effect of irrigation levels on evapotranspiration of fenugreek.
T_1=No irrigation; T_2=Irrigation at branching stage; T_3=Irrigation at branching + flowering stages; T_4=Irrigation at branching + flowering + seed development stages; T_5=Irrigation at 0.6 IW/CPE ratio; T_6=Irrigation at 0.80 IW/CPE ratio; T_7=Irrigation at 1.0 IW/CPE ratio.

Table 1. Effect of irrigation levels on consumptive use, water use efficiency and economics of fenugreek

Treatment	No. of irrigations	Crop duration (Days)	Consumptive use (mm)	WUE (kg ha^{-1} –mm^{-1})	Yield (kg ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	Benefit : Cost ratio
T_1- Control (no irrigation)	0	106	94.9	6.34	60.2	18,662	3702	1.25
T_2-Irrigation at branching stage	1	109	135.9	5.63	765.0	23,715	800	1.51
T_3-Irrigation at branching + flowering stages	2	112	176.9	5.20	920.0	28,520	12,060	1.73
T_4-Irrigation at branching + flowering + seed development stages	3	116	219.0	4.98	1091.0	33,821	16,611	1.97
T_5-Irrigation at IW:CPE at 0.6	3	114	210.3	4.85	1020.0	31,620	14,410	1.84
T_6-Irrigation at IW:CPE at 0.8	4	117	234.0	4.94	1157.0	35,687	17,907	2.00
T_7-Irrigation at IW:CPE at 1.0	5	120	268.5	4.63	1243.0	38,533	19,843	2.06
SEm ±	-	1.5	8.5	0.01	22.7	-	-	-
CD (P = 0.05)	-	4.7	26.2	0.31	69.8	-	-	-

WUE=Water use efficiency

sumptive use and water use efficiency (Table 1). The highest number of irrigations (5) was required at IW/CPE ratio 1.0 followed by IW/CPE ratio 0.8 (4). The number of irrigations was same in IW/CPE ratio 0.6 and irrigation at branching + flowering + seed development stages treatment. Crop duration increased with increasing the number of irrigations. Consumptive use was maximum when irrigation was scheduled at IW/CPE ratio 1.0 (268.5 mm) and reduced with decreasing the number of irrigation and it was minimum in no irrigation treatment. Significantly highest consumptive use was recorded at IW/CPE ratio 1.0. Singh *et al.* (1987) also observed similar findings in wheat. Though water use efficiency was higher when irrigation was scheduled at branching + flowering + seed development stages treatment as compared to IW/CPE ratio 0.8 and IW/CPE ratio 0.6, these were statistically at par with each other. Water use efficiency and consumptive use was somewhat higher at critical growth stage treatment, as compared to IW/CPE ratio approach, because in case of IW/CPE ratio treatment, irrigation water was applied on the basis of predetermined cumulative pan evaporation value irrespective of critical growth stages.

Yield

Significantly highest yield was recorded when irrigation was scheduled at IW/CPE ratio 1.0 followed by IW/CPE 0.8. Singh & Singh (1996) stated similar findings. Seed yield in irrigation at branching + flowering + seed development stages treatment was higher as compared to IW/CPE ratio 0.6 with the application of same number of irrigations. Ravindran *et al.* (2001) also suggested that irrigation at IW/CPE ratio 1.0 was beneficial for fenugreek to get higher yield.

Economics

Gross return, net return and benefit:cost ratio increased with increasing the level of irrigation both in critical stage and IW/CPE ratio approach. The highest gross return and net return were recorded at IW/CPE ratio 1.0

followed by IW/CPE ratio 0.8, irrigation at branching + flowering + seed development stages and it was lowest in no irrigation treatment. Benefit:cost ratio was highest in IW/CPE ratio 1.0 followed by IW/CPE ratio 0.8 which was also almost same as irrigation at branching + flowering + seed development stages treatment. The gross return and benefit:cost ratio at IW/CPE ratio 1.0 was more due to higher yield. The higher yield in this treatment might be due to frequent irrigations which assisted to fulfill the demand of soil moisture for better growth and development and ultimately the yielding ability of the plants increased. Gross return, net return and benefit:cost ratio were lower as compared to T_4 (irrigation at branching + flowering + seed development stages) with the same level of irrigation.

It can be concluded that scheduling of irrigation at IW/CPE ratio 1.0 was more beneficial followed by IW/CPE ratio 0.8 at branching + flowering + seed development stages to obtain higher yield and return from fenugreek.

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