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Effect of irrigation scheduling and organic manures on moisture extraction pattern, consumptive use, water use efficiency and yield of fenugreek

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Abstract

A field experiment was conducted during *rabi* season of 2010-11 and 2011-12 at Agronomy Farm, B. A. College of Agriculture, Anand, Gujarat. The study revealed that irrigation influenced the moisture extraction pattern of the crop. Higher amount of moisture was extracted from surface layer irrespective of irrigation treatment and depletion of soil moisture increased with increasing level of irrigation. Treatment I_3 (0.8 IW: CPE + 1.0 IW : CPE) recorded the maximum moisture content (9.64%) before irrigation and consumptive use (300.28 mm) among all other treatments. Treatment I_2 (0.6 IW: CPE + 1.0 IW: CPE) recorded the highest WUE (6.61 kg ha^{-1} mm) being at par with I_1 (6.51 kg ha^{-1} mm). The significantly higher grain yield (1827 kg ha^{-1}) was recorded with the irrigation applied at 0.6 IW: CPE + 1.0 IW : CPE (I_2) over all other treatments except the treatment I_3 (0.8 IW : CPE + 1.0 IW : CPE) which was also equally effective. With respect to organic manure treatments, significantly high moisture content before irrigation (9.08 %), consumptive use (279.48 mm) by crop,WUE (6.58 kg ha^{-1} mm), grain yield (1831 kg ha^{-1}) and straw yield (2712 kg ha^{-1}) was recorded under treatment M_2 (FYM 5 t ha^{-1} + CC 1 t ha^{-1}) compareed to no FYM treatment but was remained at par with M_1 (FYM).

Key words : Castor cake , consumptive use, fenugreek, irrigation, FYM, water use efficiency

Introduction

India is the largest producer and consumer of seed spices in the world. Rajasthan and Gujarat has been emerged as "seed spice bowl" which together contribute more than 80 per cent of total seed spices produced in the country and presently our country is able to meet 51 per cent of the total global demand. Fenugreek (*Trigonella foenum-graecum* L) known as *methi,* is a multipurpose crop whose every part is utilized as leafy vegetable, seed spices and condiments (Khiriya and Singh, 2003). 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. Water is a precious resource which determines successful crop production. As irrigation water is scarce and costly input, its economic and scientific utilization and optimal allocation among the different crops grown becomes quite imperative. Fenugreek is highly sensitive to water stress during the flowering and pod filling stages but excess irrigation may lead to heavy vegetative growth and shortening of reproductive period and ultimately decrease the yield.Therefore, to sustain the productivity of land and sustainability in the productivity of crop, integration of organic manures with chemical fertilizers and timing of irrigation interval with the stages of crop growth might bring about a reduction in the number of irrigations and results in an economic crop yield. Therefore, the present study was underatken to study the effect of irrigation at different phases and organic manures on growth, yield and consumptive use and water use efficiency of fenugreek (*Trigonella foenum-graecum* L.).

Material and methods

A field experiment was conducted during *rabi* seasons of 2010-11 and 2011-12 at Agronomy Farm of B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat. The soil of the experimental plot was loamy sand in texture. It was low in organic carbon and available nitrogen, while medium in available phosphorus and high in available potash with pH 7.9 and EC 0.11 dS m^{-1}.There were twelve treatment combinations comprising of four irrigation schedules and three levels of organic manures which were tested in a split plot design with four

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replications. Treatments of Irrigation schedule were relegated into the main plots and organic manures in sub plots. The treatments consisted of four irrigation schedules (vegetative and reproductive phases) *viz*., I_1: (0.6 + 0.8 IW: CPE ratio); I_2: (0.6 + 1.0 IW: CPE ratio); I_3: (0.8 + 1.0 IW: CPE ratio) and I_4 (At critical growth stages: Seedling, branching, flowering pod formation and pod development) and three levels of organic manures *viz*., M_0 (No FYM), M_1 (FYM 10 t ha^{-1}) and M_2 (FYM 5t ha^{-1} + CC 1 t ha^{-1}). A basal dose of recommended phosphorus (40 kg P_2O_5 ha^{-1}) was applied in the form of DAP to all the plots, whereas organic manures were applied as per treatments through FYM and castor cake. Fenugreek variety GF-2 was used for sowing during *rabi* seasons of both the years. The seeds were sown manually 2-3 cm deep in previously opened furrows as per the treatments with a recommended seed rate of 25 kg ha^{-1}. The quantity of irrigation water applied in each experimental plot was measured with a 7.5 cm throat size Parshall Flume installed in the main water channel near the field head. One common irrigation of 80 mm was given to all the plots for assured germination and crop establishment. Thereafter, irrigations were scheduled according to treatments viz., I_1, I_2 and I_3 based on variable IW: CPE ratio at vegetative and reproductive phases when cumulative pan evaporation (CPE) reading showed the required values with fixed depth of 50 mm water at each irrigation and in treatment $I_{4,}$ based on critical crop growth stages (Table 1). The cumulative pan evaporation (CPE) values were calculated from daily pan evaporation measured with the help of USWB Class-'A' open pan evaporimeter installed at the meteorological observatory, Agronomy Farm which was in the proximity of the experimental plot. Five critical growth stages were selected viz., early vegetative growth, branching, flowering, pod formation and pod development to apply irrigations in treatment I_4.

The data obtained on moisture percentage in each depth were used for calculating seasonal consumptive use of water and the moisture extraction pattern of fenugreek. The seasonal CU was determined by adding up PET during 24-36 hours period immediately after each irrigation Moisture depletion from soil profile**.** Effective rainfall during crop season and ground water contribution, if any. The following formula described by Dastane (1972) was used to calculate CU of water.

CU (mm) = PET (mm) 24 hours immediately after each irrigation.+ Profile soil moisture use + Effective rainfall + Ground water contribution

The depth of water table was more than 3 m below the surface throughout the period. Hence, the ground water contribution was considered as nil.

Seasonal consumptive use of water was worked out as under

$$CU = \sum_{K=1}^{N} EK \times 0.8 + \sum_{i=1}^{n} \frac{M_{1i} - M_{2i}}{100} \times ASi \times Di + ER$$

Where,

CU = Seasonal consumptive use of water (mm)

$\sum_{K=1}^{N} EK =$ The actual evaporation for the 24 hours period immediately after each irrigation from the standard USWB class A open pan evaporimeter was multiplied by 0.8 for estimated ET

$\sum_{i=1}^{n} =$ Summation of n number of layers of the root zone

M_1i = Soil moisture in the i^{th} layer of profile after 24 hours of irrigation

M_2 i = Soil moisture in the i^{th} layer of profile on the day just before the next irrigation

ASi = Bulk density of the i^{th} layer (Mg m^{-3})

Di = Depth of i^{th} layer (cm)

ER = Effective rainfall

WUE was calculated by considering the grain yield (kg ha^{-1}) and CU of water (mm) for the respective treatments by using the following formula.

$$WUE = \frac{Y}{CU}$$

Where,

WUE = Water use efficiency (kg ha^{-1} mm)

Y = Grain yield (kg ha^{-1})

CU = Consumptive use of water (mm)

For working out the economics, prevailing market prices for grain and straw and other inputs were considered. The data were statistically analyzed and the pooled results are presented.

Results and discussion

Effect of irrigation

Moisture extraction pattern showed progressive decrease in soil moisture with the depth of soil in all irrigation schedules. The maximum moisture was extracted from 0-15 cm depth followed by 15-30 cm in all irrigation treatments (Table 1a & b). The moisture extraction increased with the increase in quantity of irrigation water from upper layers of soil (0-15 and 15-30 cm) whereas almost reverse trend was observed with respect to deeper soil layers (45-60 and 60-75 cm). Higher frequency of irrigation extracted more soil moisture from upper soil

Table 1. Dates of irrigation, number of irrigations and total quantity of irrigation water applied during the experimental period, 2010-11 and 2011-12

IW/CPE ratio	Irri. No	Date of Irrigation		Irrigation interval (Days)		Number of irrigations		Irrigation water applied (cm)	
		2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
I_1: 0.6+0.8	1st	19/11/10	19/11/11	common	common				
	2nd	16/12/10	14/12/11	26	24				
	3rd	13/01/11	09/01/12	27	25	5	5	280	280
	4th	31/01/11	28/01/12	18	18				
	5th	16/02/11	11/02/12	15	14				
I_2 : 0.6+1.0	1st	19/11/10	19/11/11	common	common				
	2nd	16/12/10	14/12/11	26	24				
	3rd	13/01/11	09/01/12	27	25				
	4th	27/01/11	24/01/12	13	12	6	6	330	330
	5th	10/02/11	07/02/12	13	13				
	6th	21/02/11	18/02/12	11	10				
I_3 : 0.8+1.0	1st	19/11/10	19/11/11	common	common				
	2nd	10/12/10	07/12/11	20	18				
	3rd	01/01/11	29/12/11	21	21				
	4th	15/01/11	16/01/12	14	17	7	7	380	380
	5th	31/01/11	30/01/12	14	13				
	6th	13/02/11	10/02/12	12	10				
	7th	24/02/11	22/02/12	11	11				
I_4:At critical growth stages	1	Common		Common	Common				
	2	Early growth		18	17	6	6	330	330
	3	Branching		22	21				
	4	Flowering		17	18				
	5	Pod formation		23	21				
	6	Pod development		15	14				

Table 1a. Percentage of soil moisture extracted from different layers of soil as influenced by irrigation schedules and organic manure treatments in 2010-11

Treatment	Soil depth (cm)				
	0-15	15-30	30-45	45-60	60-75
(A) Main plot : Irrigation					
I_1	29.3	22.2	19.4	18.6	10.5
I_2	32.4	22.6	18.5	17.8	8.7
I_3	34.3	27.5	16.4	14.3	7.5
I_4	31.8	23.4	18.5	16.7	9.6
Sub plot : Organic manures					
M_0	31.1	23.2	18.0	16.2	9.0
M_1	31.9	23.9	18.2	16.7	9.1
M_2	31.8	23.8	18.4	16.8	9.2

Table 1b. Percentage of soil moisture extracted from different layers of soil as influenced by irrigation schedules and organic manure treatments in 2011-12

Treatment	Soil depth (cm)				
	0-15	15-30	30-45	45-60	60-75
Main plot : Irrigation					
I_1	27.4	20.5	19.2	18.7	14.2
I_2	30.6	22.9	17.1	16.2	13.2
I_3	34.9	23.7	18.4	13.8	9.2
I_4	31.6	22.3	18.7	16.5	10.9
Sub plot : Organic manures					
M_0	31.1	22.0	18.2	16.0	11.4
M_1	31.4	22.2	18.4	16.1	11.7
M_2	31.2	22.3	18.3	16.1	11.8

layers (0-30 cm) as compared to less number of irrigations applied to the crop probably due to more availability of moisture in soil profile which increased the potential and greater stomatal conductance. Under limited water supply (I_1) moisture availability from upper layers decreased which compelled the plants to extract more moisture from deeper layers. These results are in close proximity with those of Bhunia *et al.,,* (2006), Datta and Chatterjee (2006) and Mehta *et al.*, (2014).

Treatment I_3 (0.8 IW: CPE + 1.0 IW : CPE) recorded the maximum moisture content (9.64%) before irrigation. Significantly the lowest moisture content was retained in treatment I_1 (Table 2). The maximum moisture content in treatment I_3 might be due to more frequent irrigation during entire growth period of crop. The lowest moisture content recorded under I_1 might due to moisture stress experienced by the crop on account of longer irrigation interval. These results are also supported by the findings of Bhunia *et al.,* (2006).

Treatment I_3 (0.8 IW: CPE + 1.0 IW : CPE) exhibited significantly maximum value of consumptive use (300.28 mm) over all other treatments while the significantly lowest consumptive use was observed in I_1 treatment (237.48) (Table 2). This might be due to application of more irrigations under I_3 treatments which increased consumption of water due to better growth of crop and simultaneously the loss of water through evaporation. Inadequate moisture supply to the crop under I_1 resulted in the lowest CU of water. These findings are analogous to those reported by Nautiyal *et. al.,* (1999) and Bhunia *et. al.,* (2006).

Application of irrigation at 0.6 IW: CPE + 1.0 IW: CPE at vegetative and reproductive phase, respectively, resulted the highest WUE (6.61 kg ha^{-1} mm) being at par with I_1 (6.51 kg ha^{-1} mm) proved significantly superior over I_3 and I_4 by 10.35 and 5.42 per cent, respectively. The lowest WUE (5.99 kg ha^{-1} mm) was registered under treatment I_3 (0.8 IW: CPE + 1.0 IW: CPE). Unlike consumptive use of water, the WUE decreases with each successive increase in IW: CPE ratio. When more quantity of water was applied (I_3), the reduction in WUE could be, in higher moisture regimes more moisture is used for evaporation rather than for production, thereby reducing the WUE (Table 2). The higher WUE with lower irrigation (I_1 and I_2) might be attributed to less water loss due to evapo-transpiration under limited water supply or more diversion of photosynthates in the production of economic yield. Same results were reported by Balasio *et al.,* (2004)

Treatment I_2 recorded significantly higher field water use efficiency (5.54 kg ha^{-1} mm) over rest of the treatments and remained at par with I_1 (5.51 kg ha^{-1} mm). The reason of high FWUE under I_2 might be due to more efficient utilization of water by the crop under limited water supply during vegetative phase and optimum during reproductive phase.Similar results were also observed by Bhunia *et al.,*(2006).

Irrigation levels significantly influenced the seed and straw yield of fenugreek (Table 3). Irrigation applied at 0.6 IW: CPE + 1.0 IW : CPE (I_2) at vegetative and reproductive phases respectively, recorded significantly higher grain yield of fenugreek (1827 kg ha^{-1}) over all other treatments

Table 2. Effect of irrigation schedules and organic manures on soil moisture percentage before irrigation, CU and water use efficiency of fenugreek (pooled data of two years)

Treatments	Moisture (%) before irrigation	CU (mm)	WUE (kg ha^{-1}mm)	FWUE (kg ha^{-1}mm)
A. Main Plot :Irrigation scheduling				
I_1: 0.6 IW : CPE + 0.8 IW : CPE	7.63	237.48	6.51	5.51
I_2: 0.6 IW : CPE + 1.0 IW : CPE	9.30	275.50	6.61	5.54
I_3: 0.8 IW : CPE + 1.0 IW : CPE	9.64	300.28	5.99	4.73
I_4: At Critical growth stages	8.50	268.89	6.27	5.11
S.Em±	0.06	2.74	0.09	0.07
CD(P=0.05)	0.19	8.15	0.28	0.22
B. Sub Plot :Organic manures				
M_0: No FYM	8.42	258.40	5.94	4.66
M_1: FYM 10 t/ha	8.80	273.73	6.52	5.42
M_2: FYM 5 t/ha + CC 1 t/ha	9.08	279.48	6.58	5.59
S.Em+	0.05	2.04	0.07	0.06
CD(P=0.05)	0.13	5.79	0.19	0.16

Table 3. Effect of irrigation scheduling and organic manures on yield, nutrient content, uptake and economics of fenugreek (pooled data of two years)

Treatments	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})	Net realization (` ha^{-1})	Gross realization (` ha^{-1})	B:C ratio
A. Main Plot: Irrigation scheduling					
I_1: 0.6 IW : CPE + 0.8 IW : CPE	1544	2367	54592	78384	2.29
I_2: 0.6 IW : CPE + 1.0 IW : CPE	1827	2563	68173	92632	2.79
I_3: 0.8 IW : CPE + 1.0 IW : CPE	1796	2700	66025	91150	2.63
I_4: At Critical growth stages	1688	2576	61229	85688	2.50
S.Em$\pm$	24.24	36.85			
CD(P=0.05)	72	109			
B. Sub Plot :Organic manures					
M_0: No FYM	1530	2375	56629	77688	2.69
M_1: FYM 10 t/ha	1780	2567	65335	90284	2.62
M_2: FYM 5 t/ha + CC 1 t/ha	1831	2712	65589	92906	2.40
S.Em$\pm$	19.09	30.25			
CD(P=0.05)	54	85			

except the treatment I_3 (0.8 IW : CPE + 1.0 IW : CPE) which was also found at par (1796 kg ha^{-1}). While, in case of straw yield, irrigation practiced at 0.8 IW: CPE + 1.0 IW : CPE (I_3) produced significantly the highest straw yield of fenugreek with the value of 2700 kg ha^{-1} over 0.6 IW:CPE + 0.8 IW : CPE (I_1) which resulted the lowest straw yield. Higher yield with application of higher levels of irrigation might be due to its key role in root development by reducing mechanical resistance of soil, higher transpiration, greater nutrient uptake and more photosynthesis due to metabolic activities in the plant. These results are in conformity with the findings of Bhunia *et al.,(* 2006). The other reason of yield increase might be that scheduling irrigation at 1.0 IW: CPE ratio at reproductive phase created longer reproductive period with larger photosynthetic surface and reproductive storage capacity to attain higher allocation of net photosynthates to grain yield of fenugreek.

Treatment I_2 (Irrigations at 0.6 + 1.0 IW: CPE ratio) fetched maximum gross and net realization ('Rs 92632 and Rs. 68173 ha^{-1}, respectively), followed by treatment I_3 (Irrigations at 0.6 + 0.8 IW:CPE ratio) which realized gross and net income of ' Rs 91150 and 'Rs. 66025 ha^{-1}, respectively (Table 3).

Effect of organic manures

Soil moisture extraction slightly increased under M_1 and M_2 as compared to control. This might be due to better physical condition and root growth provided by the FYM alone (M_1) or its application with castor cake (M_2).

Significantly the highest moisture content was measured in treatment M_2 (9.08%) and the significantly lowest moisture content (8.42 %) was observed in M_0. It is obvious to mention that organic manures enhance water holding capacity of soil and also act as barrier to reduce surface evaporation and deep percolation and thereby increase the water availability in soil. These results are also in line with those of Mandal *et al.,* (2003).

The results on CU represent that the highest consumptive use (279.48 mm) by crop was shown by the treatment M_2 (FYM 5 t ha^{-1} + CC 1t ha^{-1}) which being at par with M_1 (273.73 mm) where FYM 10 t ha^{-1} was applied proved its superiority over M_0 (258.40 mm). The per cent increase in CU due to M_2 over M_0 was 8.16 (Table 2). Higher consumptive use in manure treated plots might be due to better conservation of soil moisture and reduced evaporation as compared to no manure treatment.

Organic manures also exerted significant influence on WUE. The treatment M_2 (6.58 kg ha^{-1} mm) being at par with M_1 (6.52 kg ha^{-1} mm) enhanced the WUE over M_0 (5.94 kg ha^{-1} mm) with the corresponding increase of 10.77 per cent. The reason may be ascribed to the fact that proportionate increase in grain yield was greater than the evapo-transpiration due to combined application of FYM and castor cake. Thus WUE enhanced significantly over no manure treatment where increase in yield was lesser than the loss of water through ET. Results are in close proximity with those of Kader *et al.,* (2010) .

Significantly higher grain (1831 kg ha^{-1}) and straw yield (2712 kg ha^{-1}) was recorded under treatment M_2 (FYM 5 t ha^{-1} + CC 1 t ha^{-1}) over M_0 by 19.67 and 14.19 per cent, respectively. However, it remained at par with M_1 (FYM 10 t ha^{-1}) in case of grain yield. The higher grain and straw yield under treatment M_2 might be attributed to the favourable effect of organic manures which play a key role in root development, energy translocation and metabolic processes of plant through which increased translocation of photosynthates towards the sink development might have occurred. Further, application of castor cake with low C: N ratio in combination with FYM (wide C: N ratio) might have increased the mineralization process which resulted into increased availability of nutrients to the crop. The beneficial effect of combine use of (FYM and CC) organic manure on seed and straw yields could be attributed to the fact that proper decomposition and mineralization of organic manures supply available P with other essential plant nutrients directly to the plant and also solubility effects on fixed form of P in legumes (Poonia and Jat, 2008). These findings are in close agreement with those reported by Kanwar *et al*., (2002) and Khiriya and Singh (2003).

Treatment M_2 (FYM 5 t ha^{-1} + CC 1 t ha^{-1}) resulted maximum gross and net realization of Rs'92906 and Rs.65589 ha^{-1}, respectively followed by treatment M_1 (FYM 10 t ha^{-1}) with the gross and net realization of Rs. 90284 and Rs. 65335 ha^{-1}, respectively.

Thus, it is concluded that application of irrigation at 0.6 IW: CPE ratio (21-27 days interval) during vegetative phase and 1.0 IW: CPE ratio (10-12 days interval) during reproductive phase with FYM @ 5t/ha +Castor Cake @1.0 t/ha is beneficial for realizing, higher yield, net benefit and saving of water

References

Balasio, E. D., Hussein, A. and Ahmed, M. A. 2004. Effect of watering regimes at two stages of growth on faba bean grain yield at Selain Basin. *Agronomy Journal*, 75-80.

Bhunia, S. R., Chauhan, R. P. S., Yadav, B. S. and Bhati, A. S. 2006. Effect of phosphorus, irrigation and *Rhizobium* on productivity, water use and nutrient uptake in fenugreek (*Trigonella foenum- graecum* L). *Indian J. Agronomy,*51(3): 239-241.

Dastane, N. G. 1972. A Practical Manual for Water use Research in agriculture. 2^{nd} edition Pune, Navbharat Prakashan.

Datta, S. and Chatterjee, R. 2006. Effect of irrigation regimes on moisture extraction pattern, evapo-transpiration and yield of fenugreek (*Trigonella foenum-graecum* L.). *J. Spices and Aromatic Crops*, 15 (2): 125-129.

Kader, A. E., Shaaban, S. M., and A. E.- Fatah, M. S. 2010. Effect of irrigation levels and organic compost on okra plants grown in sandy calcareous soil. *Agriculture and Biology J. North America*, 1(3): 225-231.

Kanwar, K., Paliyal, S. S. and Kamla K. 2002. Influence of phosphorus management and organic manuring on uptake and yield of chickpea. *Annals of Agricultural Research*, 23 (4): 642-645.

Khiriya, K. D. and Singh, B. P. 2003. Effect of phosphorus and farmyard manure on yield, yield attributes and nitrogen, phosphorus and potash uptake of fenugreek (*Trigonella foenum-graecum* L). *Indian J. Agronomy,* 48 (1): 62-65.

Mandal, K. G., Hati, K. M., Misra, A. K. and Bandyopadhyay, K. K. 2003. Assessment of irrigation and nutrient effects on growth, yield and water use efficiency of Indian mustard in central India. *Agricultural water management,* 85 (3): 279-286.

Mehta, R. S., Patel, B. S., Meena, S. S., Lal, G. and Singh, R. 2014. Water dynamics and yield of fenugreek (*Trigonella-foenium-graecum* L.) as influenced by irrigation scheduling and weed management practices. *Int. J. Seed Spices* 4(2):42-46

Nautiyal, P. C., Zala, P. V. and Joshi, Y. C. 1999. Enhancement of yield in groundnut following the imposition of transient soil-moisture-deficit stress during the vegetative phase. *Experimental Agriculture* 35: 371-385.

Poonia, K. L. and Jat, R. N. 2008. Effect of organic manure and fertilizer on productivity of nagauri pan methi (*Trigonella corniculata* L.). *J. Arid Legumes,* 5(2) : 140-141.Prakashan.702- Budhawar Path Poona-2.

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