

Influence of irrigation scheduling and weed management practices on growth and yield of Fenugreek (*Trigonella foenum-graecum* L.)

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Abstract

A field experiments were conducted in two successive rabi seasons, 2016-17 and 2017-18, at the Instructional Farm of Rajasthan College of Agriculture, Udaipur situated in the Sub Humid Southern Plain and Aravalli Hills of the state of Rajasthan, India to determine irrigation and weed management can improve fenugreek (*Trigonella foenum-graecum* L) growth performance and competitiveness with weeds, thus helping to achieve its yield potential. The experiment consisted of four irrigation levels (0.4, 0.6, 0.8 and 1.0 IW/CPE ratio) and four weed management treatments (Weedy check, PE application of pendimethalin + imazethapyr (RM) 0.75 kg ha⁻¹ in conjugation with one hand weeding 40 DAS, imazethapyr 0.075 kg ha⁻¹ 20 DAS followed by hand weeding 40 DAS and two hand weeding 20 and 40 DAS) thereby making sixteen treatment combinations. Amongst irrigation schedules irrigation at 0.8 IW/CPE ratio recorded significant improvement in various growth and yield parameters during both the years of study. PE application of pendimethalin + imazethapyr (RM) in conjugation with one hand weeding achieved the highest weed depression expressed in the lowest dry matter of broad-leaved, narrow-leaved and total weeds. Also, this treatment was the most superior treatment in increasing plant height and crop dry matter, primary branches plant⁻¹, crop growth rate, nodulation, pods plant⁻¹, seeds pod⁻¹, test weight, seed yield plant⁻¹, pod length and seed weight pod⁻¹ of fenugreek.

Keywords: Fenugreek, Irrigation schedule, Weed management, IW/CPE ratio

Introduction

Historically, India has always been recognized as a land of spices. Rajasthan and Gujarat has been emerged as “seed spice bowl” and together contributes more than 80 per cent of total seed spices produced in the country. Fenugreek (*Trigonella foenum graecum* L.) is a leguminous seed spices in North-Western India as an important condiment crop during winter season. It is a multipurpose crop and has several medicinal uses. It's seeds substantially contain the steroid substances diosgenin which is used as a base material in the synthesis of sex hormones in oral contraceptive. India occupies prime position among the fenugreek growing countries of the world. In India it is mainly grown in Rajasthan, Madhya

Pradesh, Gujarat, Haryana, Uttar Pradesh and Tamil Nadu. On national basis, during the year 2020-21, fenugreek occupied an area of 156156 ha with production and productivity of 241183 tonnes and 1544 kg ha⁻¹, respectively (Spice Board, 2022). Among the states in India, Rajasthan is the largest fenugreek producing state with contributes 45.30 per cent of total production and occupies an area of 90469 ha with the production of 109280 tonnes during *Rabi* 2020-21 (Spice Board, 2022). Water management has become the most indispensable factor for augmenting the crop productivity especially in legume crops because of their high susceptibility to both water stress and water logging at various growth stages. Irrigation should aim to restore soil water in the root zone to a level at which crop can fully meet its evaporation requirement. Different criteria were employed to supply water to the crop so that it does not experience the water stress at many stages of the crop growth and development. Recently irrigation is being scheduled on the basis of climatologically approach which is now considered as most scientific, since it integrate all weather parameters giving the natural weight age in a given climate plant continuum. In climatologically approach (IW/CPE), a known amount of irrigation water is applied when cumulative pan evaporation reaches at predetermine level. Weed is an important factor responsible for causing tremendous loss in fenugreek. Due to slow initial growth of fenugreek, it is more susceptible to weed problem hence simultaneous emergence and rapid growth of weed leads to severe weed crop competition for light, moisture, space and nutrients. In agriculture, weed causes more damage as compared to insect pest and diseases due to hidden losses caused by weed in crop production. If unchecked, it may reduce the seed yield to the tune of 14.2 to 69 % depending upon their density and duration of competition (Chovatia *et al.*, 2009). The presence of weeds is causing a shortage of the crop up to 40% (Soliman *et al.*, 2015). The advantages of herbicide application are characterized by high efficiency in weed control, high selectivity and at the lowest cost, compared to other available weed control methods. Manual weeding is time consuming, back breaking and expensive, therefore; under such conditions use of herbicide remains the pertinent choice of farmers for controlling the weeds. Precise information on water and weed management in fenugreek is essential and inevitable. Hence, the study was carried out to evaluate effect of irrigation scheduling and weed management practices on growth and yield of fenugreek.

Materials and Methods

The field experiment was conducted during *Rabi* season of 2016-17 and 2017-18 at Instructional Farm of Rajasthan College of Agriculture, Udaipur situated in the Sub Humid

Southern Plain and Aravalli Hills of the state of Rajasthan. The soil of the experimental field of both the location was clay loam in texture having pH (8.1 and 8.0), electrical conductivity (0.89 and 0.84 dS/m), medium in organic carbon (0.76 and 0.68), medium in available nitrogen (400.50 and 372.80 kg ha⁻¹), medium in available P₂O₅ (24.80 and 20.70 kg ha⁻¹) and high in available K₂O (378.20 and 342.40 kg ha⁻¹) respectively during 2016-17 and 2017-18. The experiment was laid out in split plot design with four replications, keeping four levels of irrigation (0.4, 0.6, 0.8 and 1.0 IW/ CPE ratios) in main plot and four weed control treatments (Weedy check, pre emergence application of pendimethalin + imazethapyr (RM) 0.75 kg ha⁻¹ in conjugation with one hand weeding 40 DAS, imazethapyr 0.075 kg ha⁻¹ 20 DAS followed by hand weeding 40 DAS and two hand weeding 20 and 40 DAS) in sub plots. The fenugreek variety RMT - 305 was sown at 30 cm row to row spacing keeping seed rate of 25 kg per ha. Full dose of nitrogen and phosphorus was drilled manually through DAP and urea at the time of sowing. Cumulative pan evaporation was taken as the sum of the daily pan evaporation from USWB class-A. Irrigation water was measured by Parshall flume installed in the field channel. As per treatment, pre emergence herbicide pendimethalin + imazethapyr (Ready mix) @ 0.75 kg ha⁻¹ was applied two DAS of crop while imazethapyr @ 0.075 kg ha⁻¹ was applied 20 DAS. These herbicides were sprayed with knapsack sprayer fitted with flat fan nozzle using 500 litres of water per hectare after calibration. Hand weeding treatments comprised of hoeing and weeding operation 20 and 40 DAS performed with hand hoe.

Results and discussion

Effect of irrigation levels

Significantly higher plant height at different growth stages was recorded with irrigation at 0.8 IW/CPE ratio over 0.4 and 0.6 IW/CPE ratio during both the years as well as in pooled analysis (Table 1). Further enhancement in levels of irrigation failed to significantly influenced plant height. The higher plant growth with 0.8 IW/CPE ratio might be attributed to maintenance of favourable and congenial moisture regime due to application of frequent irrigation which facilitated better water and nutrient absorption resulting in higher plant height. Significantly higher dry matter accumulation, CGR, RGR, number of nodules plant⁻¹, nodule dry weight was obtained with irrigation at 0.8 IW/CPE ratio which might be due to optimum availability of moisture at 0.8 IW/CPE ratio without any stress resulting in higher vegetative growth, more photosynthetic area and dry matter accumulation resulting in higher CGR and RGR. Significant enhancement in yield attributes *viz.*, pods plant⁻¹, seeds pod⁻¹, test weight, seed yield plant⁻¹, pod length and seed weight pod⁻¹ were recorded under 0.8 IW/CPE ratio compared to 0.4 and 0.6 IW/CPE ratio. This proves that IW/CPE ratio of 0.8 maintained

most optimum soil moisture for better growth parameters i.e., dry matter accumulation, plant height, branches plant⁻¹, crop growth rate, relative growth rate, nodules plant⁻¹; result in better yield attributes and yield performance of fenugreek crop during both the years of investigation and pooled basis. This significant enhancement in performance of yield attributes and yield components can be ascribed to greater availability of photosynthetes and its translocation towards the formation of reproductive organs that resulted not only in formation of significantly a greater number of pods plant⁻¹ but it also significantly improved the pod and seed health (pod length, more seeds pod⁻¹, bold seed size and finally seed yield plant⁻¹). Significantly higher pooled values of seed yield (3244 kg ha⁻¹), haulm (6302 kg ha⁻¹), biological yield (9546 kg ha⁻¹) and harvest index (33.57 %) of fenugreek were obtained under 0.8 IW/CPE ratio.

Effect of irrigation and weed management practices on plant height and crop dry matter on pooled basis

Treatments	Plant Height (cm)				Crop Dry matter (g plant ⁻¹)			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Irrigation Management								
I₀ (0.4 IW/CPE)	10.0	32.7	40.3	42.1	0.57	4.45	15.15	18.60
I₁ (0.6 IW/CPE)	12.4	38.6	44.8	46.0	0.84	6.43	18.35	23.97
I₂ (0.8 IW/CPE)	15.1	45.3	54.1	55.3	0.92	8.11	20.75	30.88
I₃ (1.0 IW/CPE)	15.5	45.4	54.9	56.3	0.94	8.27	20.83	31.60
SEm ±	0.2	0.3	0.5	0.5	0.01	0.08	0.15	0.26
CD (P= 0.05)	0.6	1.0	1.3	1.4	0.02	0.23	0.45	0.78
Weed Management								
W₀	11.0	34.9	42.0	42.7	0.64	4.19	14.30	19.29
W₁	14.7	43.6	52.2	54.2	0.92	8.20	21.32	29.49
W₂	12.8	40.3	48.1	49.6	0.80	6.71	18.56	27.13
W₃	14.5	43.2	51.8	53.3	0.91	8.16	20.90	29.14
SEm ±	0.1	0.2	0.2	0.4	0.01	0.06	0.16	0.18
CD (P= 0.05)	0.4	0.6	0.7	1.0	0.03	0.16	0.45	0.51

W₀ – Weedy check, W₁ – PE pendimethalin + imazethapyr (RM) fb one HW 40 DAS, W₂ – Imazethapyr + one HW 40 DAS, W₃ – Two HW 20 and 40 DAS

Effect of irrigation and weed management practices on growth attributes of fenugreek viz. CGR, Primary branches plant⁻¹, Number of nodules and their dry weight, Days to 50 % flowering and Days to maturity on pooled basis

Treatments	Crop growth rate (g m ⁻² day ⁻¹)		Primary branches plant ⁻¹ at 75 DAS	Number of nodules plant ⁻¹		Dry weights of nodules plant ⁻¹ (mg plant ⁻¹)		Days to 50 % flowering	Days to maturity
	Between 30- 60 DAS	Between 60- 90 DAS		40 DAS	60 DAS	40 DAS	60 DAS		
Irrigation Management									
I₀ (0.4 IW/CPE)	4.31	11.89	4.88	12.31	21.60	27.33	51.05	53.7	117.7
I₁ (0.6 IW/CPE)	6.21	13.25	5.51	16.51	24.52	39.12	69.53	55.1	126.4
I₂ (0.8 IW/CPE)	7.99	14.04	6.29	19.74	26.05	45.03	81.41	61.1	131.0
I₃ (1.0 IW/CPE)	8.14	13.95	6.43	20.15	26.70	46.29	82.29	61.3	132.3
SEm ±	0.08	0.13	0.07	0.20	0.26	0.57	0.45	0.5	0.8
CD (P= 0.05)	0.24	0.40	0.20	0.60	0.77	1.71	1.32	1.5	2.4
Weed Management									
W₀	3.94	11.23	4.55	11.78	19.49	25.24	57.20	62.3	123.8
W₁	8.08	14.59	6.44	20.01	27.91	46.02	75.63	55.6	129.5
W₂	6.57	13.16	5.78	16.48	23.15	39.54	70.32	58.4	126.6
W₃	8.05	14.15	6.35	20.44	28.33	46.98	81.13	55.0	127.5
SEm ±	0.07	0.19	0.04	0.18	0.16	0.35	0.44	0.4	0.7
CD (P= 0.05)	0.19	0.54	0.11	0.52	0.45	0.97	1.22	1.2	2.0

W₀– Weedy check, W₁– PE pendimethalin + imazethapyr (RM) fb one HW 40 DAS, W₂ – Imazethapyr + one HW 40 DAS, W₃– Two HW 20 and 40 DAS

Effect of irrigation and weed management on yield attributes of fenugreek on pooled basis

Treatments	Pods plant ⁻¹	Seeds pod ⁻¹	Test weight (g)	Seed yield plant ⁻¹ (g)	Pod length (cm)	Seed weight pod ⁻¹ (g)
Irrigation Management						
I₀ (0.4 IW/CPE)	44.9	11.9	11.92	6.43	10.2	0.164
I₁ (0.6 IW/CPE)	51.7	13.2	14.51	9.95	10.9	0.220
I₂ (0.8 IW/CPE)	61.0	16.9	18.04	16.78	11.7	0.351
I₃ (1.0 IW/CPE)	61.8	17.2	18.28	17.23	11.8	0.354
SEm ±	0.6	0.2	0.10	0.16	0.1	0.004
CD (P= 0.05)	1.7	0.7	0.30	0.49	0.3	0.011
Weed Management						
W₀	44.7	12.1	12.38	7.22	10.2	0.170
W₁	60.2	16.5	17.86	15.12	11.8	0.341
W₂	54.9	14.4	14.85	13.10	10.9	0.245
W₃	59.6	16.2	17.67	14.95	11.7	0.334
SEm ±	0.3	0.1	0.09	0.11	0.1	0.003
CD (P= 0.05)	0.7	0.4	0.26	0.30	0.2	0.008

W₀ – Weedy check, W₁ – PE pendimethalin + imazethapyr (RM) fb one HW 40 DAS, W₂ – Imazethapyr + one HW 40 DAS, W₃ – Two HW 20 and 40 DAS

Effect of irrigation and weed management on yield and economics of fenugreek on pooled basis

Treatments	Seed Yield (Kg ha ⁻¹)	Haulm Yield (Kg ha ⁻¹)	Biological Yield (Kg ha ⁻¹)	Harvest Index (%)	Net Return (Rs ha ⁻¹)	B/C Ratio
Irrigation Management						
I₀ (0.4 IW/CPE)	1571	4191	5762	26.83	27689	0.90
I₁ (0.6 IW/CPE)	2397	5511	7908	29.96	55099	1.72
I₂ (0.8 IW/CPE)	3244	6302	9546	33.57	80779	2.38
I₃ (1.0 IW/CPE)	3312	6427	9739	33.59	82168	2.35
SEm ±	52	79	122	0.33	1719	0.06
CD (P= 0.05)	154	236	363	0.97	5108	0.17
Weed Management						
W₀	1642	4107	5750	28.23	31578	1.09
W₁	3142	6264	9406	32.74	78267	2.35
W₂	2648	5863	8511	30.33	61336	1.79
W₃	3092	6196	9288	32.66	74554	2.11
SEm ±	30	50	57	0.31	915	0.03
CD (P= 0.05)	84	139	161	0.86	2570	0.08

W₀ – Weedy check, W₁ – PE pendimethalin + imazethapyr (RM) fb one HW 40 DAS, W₂ – Imazethapyr + one HW 40 DAS, W₃ – Two HW 20 and 40 DAS

Application of irrigation at 0.8 IW/CPE ratio resulted in 94.18 and 34.81; 50.37 and 14.35; 65.67 and 20.71 per cent hike in pooled seed, haulm and biological yields, respectively over 0.4 and 0.6 IW/CPE ratio. No doubt, weed density and weed dry weight increased steadily with increasing in number of irrigation but at the same time seed yield was also increased. This might be due to fact that increased irrigation frequency, decreased the soil moisture stress which in turn resulted in higher leaf water potential, stomatal conductance and higher photosynthesis consequently increased dry matter production and ultimately higher seed yield. Data further striking that increase in seed, haulm and biological yield on increasing IW/CPE ratio from 0.6 to 0.8 was higher than the corresponding increase on raising IW/CPE ratio from 0.4 to 0.6 which reveals that IW/CPE ratios of 0.8 and 1.0 not only maintained sufficient soil moisture at critical stages of fenugreek crop but it met out the physiological, structural and metabolic requirements of fenugreek crop apart from meeting out the evapo-transpiration demand of crop. It also be due to increasing irrigation numbers might have caused faster growth of fenugreek plants and inhibited weed seed germination and the growth of early emerged weeds, which in turn, reduced the weed-crop competition resulting into higher seed yield.

Effect of weed management

The major weed flora of the experimental field were *Chenopodium murale*, *Chenopodium album*, *Convolvulus arvensis*, *Melilotus indica*, *Cyperus rotundus*, *Cynodon dactylon* and *Phalaris minor* which were controlled by different weed management techniques. At each stage of observation pre emergence application of pendimethalin + imazethapyr (RM) followed by one hand weeding recorded significantly higher plant height, crop dry matter, CGR, branches plant⁻¹, nodules plant⁻¹, nodules dry weight plant⁻¹, however, its effect was statistically at par with two hand weeding. This might be due to severe competition by weeds for growth resources which made the crop plants inefficient to take up moisture and nutrients, consequently affected growth adversely. In general, the aforesaid improvements seems to be on account of direct impact of different weed management treatments through least crop-weed competition whereas, indirect effect might be least competition for plant growth inputs viz., light, space, water, nutrients etc. Similarly, under reduced density and dry matter of weeds, plants get sufficient space for optimum expansion of leaves and branches as early as possible. Under present investigation superiority of pre-emergence application of pendimethalin + imazethapyr (RM) along with one hand weeding could be ascribed due to their direct effect on reduced density and dry matter of weeds while indirect effect might be on account of improvement in nutrient uptake by crop compared to weedy check. Thus, congenial nutritional environment might have increased metabolic processes in plant resulting in greater plant height, thereby

improving branches and ultimately resulting in higher dry matter accumulation plant⁻¹. Pre emergence application of pendimethalin + imazethapyr (RM) *fb* one hand weeding produced significantly higher pooled values of seed (3142 kg ha⁻¹), haulm (6264 kg ha⁻¹) and biological yield (9406 kg ha⁻¹), compared to rest of the weed management treatments except two hand weeding. Pre emergence application of pendimethalin + imazethapyr (RM) *fb* one hand weeding and two hand weeding resulted in 91.35 and 88.31; 52.52 and 50.86; 63.58 and 61.53 per cent hike in pooled seed, haulm and biological yield, respectively over weedy check . The significantly improvement in seed yield as a result of pre emergence application of pendimethalin + imazethapyr (RM) followed by one hand weeding and two hand weeding could be ascribed to the fact that yield of crop depends on several yield component which are interrelated. Under weedy situation, at early crop growth stage a greater part of resource present in soil and environment are depleted by weeds for their growth. The crop plants thus, faced stress which ultimately affected their growth, development and yield. Alike seed yield, haulm yield was also significantly increased under various treatment of weed management during the experiment over weedy check. Increase in haulm yield might be due the direct influence of various weed management treatments on the suppression of weeds. Thus, decrease crop weed competition resulted into increase plant height, crop dry matter accumulation, leaf area index, number of nodules plant⁻¹ and branches plant⁻¹. Tiwari *et al.*, (2006), Chovatia *et al.*, (2007), Mehta *et al.*, (2010) also reported similar results in fenugreek.

CONCLUSION

It seems quite logical to conclude that higher production and net return from the fenugreek can be secured by scheduling irrigation at 0.8 IW/CPE ratio and efficient weed control can be achieved either by pre-emergence application of pendimethalin + imazethapyr (RM) along with one hand weeding 40 DAS under paucity of farm labourers or two hand weeding 20 and 40 DAS under availability of farm labourers.

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