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Water dynamics and yield of fenugreek (*Trigonella-foenium-graecum* L.) as influenced by irrigation scheduling and weed management practices

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Abstract

In a field experiment, at Sardarkrushinagar, Gujarat during 2006-07 and 2007-08 comprising of three irrigation levels (Irrigation water/Cumulative Pan evaporation Ratio of 0.6, 0.8 and 1.0) in main plot and six levels of weed management practices (weedy check, weed free, Hand Weeding (HW) at 20 and 40 DAS, HW at 20 and IC at 40 DAS, application of Pendimethalin @ 0.75 kg ha^{-1} (PE) and application of Pendimethalin @ 0.75 kg ha^{-1} (Pre-emergence) + Inter-culturing at 40 DAS) place in sub plot, it was found that nearly 73 and 27 per cent soil moisture was extracted by root system of fenugreek plant from 0-45 and 45-75 cm soil profile, respectively. In upper soil profile of 0-15 and 15-30 cm relatively higher amount of soil moisture was extracted at 1.0 IW/CPE ratio but in lower soil profile extraction of soil moisture was found more at lower IW/CPE ratio. The highest consumptive use of water (409.89mm) seed yield (1474 kg/ha) and straw (2835but higher water use efficiency (3.94 kg ha^{-1}mm^{-1}), and water expanse efficiency (3.37 kg ha^{-1} mm^{-1}) was recorded with 0.8 IW/CPE ratios. Higher soil moisture at 0-15,15-30 and 30-45 cm soil profile was extracted in weedy check but from lower soil profile i.e. 45-60 and 60-75 cm weed free treatment followed by pre-emergence application of Pendimethalin @ 0.75 kg ha^{-1} (PE) + IC at 40 DAS) extracted more soil moisture compared to other treatments.The highest consumptive use of water was recorded in weedy check but WUE and WEE as well as seed, and straw yields were obtained highest in weed free being at par with Pendimethalin @ 0.75 kg per ha +IC at 40 DAS and HW at 20 and 40 DAS. Thus, irrigation at 1.0 IW/CPE ratio along with Pendimethalin @ 0.75 kg ha^{-1} (PE) + IC at 40 DAS) is recommended to get maximum yield

Key words : Consumptive use of water, moisture extraction pattern, water use efficiency, water expanse efficiency.

Introduction

Fenugreek locally known as *Methi* is an important multipurpose winter season seed spice crop mainly grown in Rajasthan, Gujarat, Madhya Pradesh Maharashtra, Haryana, Punjab, Bihar and Andhra Pradesh. The seeds of fenugreek are used as a condiment and seasoning agent for garnishing and flavourings dishes and it has many medicinal properties like diuretic, tonic, carminative and aphrodisiac (Meena *et al*.7). In most part of the Asia, water is increasingly becoming scarce and costly. Per capita availability of water has declined in many Asian countries by 40 to 60 per cent during 1955 to 1990 (Gleik,4).Moreover, water is an indispensable for every metabolic activity of plant. In the world, specifically in arid and semi arid regions water is an important limiting factor for crop production. It is a precious resource which determines successful crop production. Water requirement of fenugreek is 300-350 mm and irrigation water is scarce and costly input in crop production. Application of water based on IW/CPE ratio is a scientific approach for saving of water in fenugreek to realise higher water use efficiency. Simultaneous emergence and rapid growth of weed in fenugreek leads to severe weed crop competition for light, moisture, space and nutrients which accounts nearly 60-70 percent loss of yield in fenugreek. Very less information's on weed and water management in fenugreek are available, hence the study on Influence of irrigation levels and weed management practices on water use efficiency and yield of fenugreek was conducted with an object to find optimum irrigation level and weed management practices for higher yield and water use efficiency.

Materials and methods

A field experiment was conducted at Sardarkrushinagar during *rabi* season of 2006-07 and 2007-08. The soil of the experimental field was loamy sand in texture having pH 7.75 and 7.73 and electrical conductivity 0.12 and 0.11 dSm^{-1}, respectively during 2006-07 and 2007-08. The

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soil of the experimental field of both the sites was low in organic matter, available nitrogen, and medium in available phosphorus and good in respect to available potassium. The experiment was laid out in split plot design with four replications, keeping three levels of irrigation (0.6, 0.8 and 1.0 IW/CPE ratios) in main plot and six weed control treatments (weedy check, weed free, hand weeding at 20 and 40 DAS, HW at 20 + Inter –culturing at 40 DAS, application of Pendimethalin @ 0.75 kg ha^{-1} (PE) and application of Pendimethalin @ 0.75 kg ha^{-1} (PE) + IC at 40 DAS) in sub plots. The fenugreek variety GM-2 was sown in second week of November during both the years at 30 cm row to row spacing keeping seed rate of 20 kg per ha. 25 kg N nitrogen and40 kg P_2O_5 was drilled manually through DAP and urea at the time of sowing. Two common irrigations each of 50 mm depth were applied at sowing and 5 DAS for good germination and establishment of crop and afterward irrigations were applied as per treatment. 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. Application of Pendimethalin @ 0.75 kg per ha (PE) was done on second day after irrigation with the help of a knapsack sprayer with spray volume of 600 litres per ha. In manual weed control treatments, weeds were uprooted and removed at 20 and 40 DAS and inter-culturing was done as per treatments at 40 DAS. In weed free plots, the weeds were removed manually after every seven days for ensuring complete weed free condition. The soil samples for soil moisture studies were taken from each layer of 15 cm up to 75 cm with the help of screw auger and were dried at 105 ^{o}C temperature for eight to ten hours till constant weight was obtained. Moisture depleted from each layer was calculated by adding all the short period depletion at the respective depth till maturity of the crop and the percentage depletion at various depths to the total was worked out. Water use efficiency and water expense efficiency was calculated with following formula

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

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

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

CU = Consumptive use of water (mm)

$$\mathrm{WEE} = \frac{\mathrm{Y}}{\mathrm{WA}}$$

Where, WEE = Water expense efficiency (kg ha^{-1}-mm)

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

WA = Water applied (mm)

Moisture percentage and consumptive use of water were worked out by using formula suggested by Dastane (2).

Results and discussion

Soil moisture extraction pattern

Soil moisture extraction pattern revealed that magnitude of soil moisture extraction decreased progressively with increasing depth of soil profile. Contribution of upper 0-45 cm soil layer in soil moisture extraction was higher (>70%) than that of lower (45-75 cm) layers. Relatively higher amount of moisture extracted from 0-15 and 15-30 cm soil layer by the crop under 1.0 IW/CPE ratio (33.26 and 25.02 %) followed by 0.8 (31.92 and 23.4 %) and 0.6 (30.03 and 22.51 %) IW/CPE ratio but at lower soil profile i.e 30-45,45-60 and 60-75 cm relatively higher soil moisture was extracted by crop under irrigation at 0.6 IW/CPE ratio followed by 0.8 and 1.0 IW/CPE ratio (Table 1).This might be due to sufficient amount of available soil moisture in the upper soil layer with low tension on account of frequent water supply and concentration of roots in upper soil layer only, hence, under such condition rate of water absorption was higher but at lower soil profile the higher water absorption at lower IW/CPE ratio was due to the fact that under water deficit situation root goes in deeper soil layer in search of moisture which result higher water absorption at lower IW/CPE ratio. Similar findings were reported, Dutta *et al. (*3) in fenugreek.

Relatively higher amount of moisture extracted from 0-15 cm soil layer by the crop in weedy check (33.25%) followed by the application of Pendimethalin @ 0.75 kg ha^{-1} (32.02 %).The higher moisture extraction from upper soil layer is due to presence of higher weed canopy through out the growth period from. Proportionately higher soil moisture was extracted by the crop in weed free as well as with application of Pendimethalin @ 0.75 kg ha^{-1}(PE) + IC at 40 DAS and HW at 20 and 40 DAS from lower soil layer as compared to other treatments (Table-1). This might be due to the fact that effective control of weeds under these treatments creates favourable conditions for good root development of the crops which in turn facilitate proportionately higher soil moisture extraction from lower layers of the soil.

Consumptive use of water and water use efficiency

Consumptive use of water (CU) was observed highest with irrigation at 1.0 IW/CPE ratio but water use efficiency and water expanse efficiency was recorded the highest with irrigation at 0.8 IW/CPE ratio. The lowest CU, WEE and WUE was recorded with irrigation at 0.6 IW/CPE ratio. (Table 2). This might be on account of ease with which moisture was available for crop growth due to more number of irrigations resulted in application of more quantity of water which enhance the CU of water by luxuriant growing plant body which in turn increased the evapo-transpiration losses. Frequent irrigation maintained wet surface for longer period which consequently lead to higher loss of moisture due to evaporation. The higher CU of water at 1.0 IW/CPE ratio reduce WUE due to less proportionate increase in yield but at 0.8 IW/CPE ratio WUE was highest on account of higher seed yield obtained proportion to quantity of water used as compared to other treatments. These findings are similar to those reported Patel *et al*. (8) in fennel.

Significantly the highest CU of water was recorded in weedy check followed by application of Pendimethalin @ 0.75 kg ha^{-1}(PE) and the lowest CU of water was observed in weed free treatment followed by application of Pendimethalin @ 0.75 kg ha^{-1}(PE) + IC at 40 DAS. (Table 2). In weedy check, higher CU of water might be due to presence of higher weed canopy, which resulted more evapo - transpiration of water. Moreover, weed free treatment exhibited significantly the lowest CU of water due to nearly absence of weeds and evapo-transpiration is only on account of presence of crop plants. Significantly the highest WUE and WEE were recorded in weed free treatment being at par with application of Pendimethalin @ 0.75 kg ha^{-1} (PE)+ IC at 40 DAS and HW at 20 and 40 DAS. The lowest WUE and WEE were obtained in weedy check followed by application of Pendimethalin @ 0.75 kg ha^{-1}(PE) (Table 2).This might be due to lower CU of water in weed free treatment and higher CU of water in weedy check resulted higher and lower WUE and WEE, respectively.

Seed and straw yield of fenugreek

Application of irrigation at 1.0 IW/CPE ratio exhibited significantly higher seed (1474 kg ha^{-1}) and straw yield (2835 kg ha^{-1}) of fenugreek over 0.8 and 0.6 IWCPE ratio (Table 1). Application of irrigation at 1.0 IW/CPE ratio resulted 10 and 38 per cent higher seed yield over 0.8 and 0.6 IW/CPE ratio respectively. The increase in seed and straw with application of irrigation at 1.0 IW/CPE ratio could be explained by the fact that frequent irrigations under this treatment facilitated maintenance of optimum moisture level in soil as well as in plant during entire growth period which resulted better translocation of photosynthates from source to sink. These findings are in close agreement with those of Dutta *et al*. (3)

Besides weed free treatment, pre emergence application of Pendimethalin @ 0.75 kg ha^{-1} + IC at 40 DAS resulted significantly the highest yield followed by hand weeding at 20 and 40 DAS which were being at par with weed free (Table2) .Effective weed control lead to congenial conditions for growth and development of crop which ultimately resulted higher yield. Patel *et al*. (8) and Meena and Mehta (5) in fennel also reported similar results

Seed and straw yields were significantly influenced with interaction effect between irrigation levels and weed management practices. The highest seed, straw and biological yields were obtained by application of irrigation at 1.0 IW /CPE ratio with weed free treatment which was at par with irrigation at 1.0 IW/CPE ratio and pre emergence application of Pendimethalin @ 0.75 kg ha^{-1} + IC at 40 DAS and irrigation at 1.0 IW/CPE with HW at 20 and 40 DAS which might be due to effective weed control with application of Pendimethalin@ 0.75 kg ha^{-1}(PE) + IC at 40 DAS and HW at 20 and 40 DAS along with adequate availability of moisture at 1.0 IW/CPE ratio resulted congenial growth and development condition for higher seed, straw and biological yields. The results are in close conformity with those reported by Bhimani (1) in mustard and Meena and Mehta (6) in coriander.

Thus, application of irrigation at 1.0 IW/CPE ratio along with Pendimethalin @ 0.75 kg ha^{-1} (PE) + IC at 40 DAS) is better for getting higher yield of fenugreek and water use efficiency.

Table 1: Soil moisture extraction pattern as influenced by irrigation levels and weed management practices Pooled of year 2006-07 and 2007-08)

Treatment	Soil depth (cm) 0-15	15-30	30-45	45-60	60-75
Main plot (IW/CPE ratio)					
0.6	30.03	22.51	17.95	15.28	14.20
0.8	31.92	23.40	17.21	14.19	13.6
1.0	33.26	25.02	16.52	13.20	12.09
Mean	31.74	23.71	17.19	14.21	13.15
Sub- plot (Weed management practices)					
	0-15	15-30	30-45	45-60	60-75
Weedy check	33.25	25.39	17.94	13.07	10.31
Weed free	31.09	22.43	16.40	15.24	14.85
HW at 20 and 40 DAS	31.31	23.29	17.45	14.62	13.35
HW at 20 DAS and IC at 40 DAS	31.59	23.72	17.30	13.89	13.50
Pend@0.75 kg ha^{-1}(PE)	32.02	24.34	17.65	13.54	12.47
Pend@ 0.75 kg .ha^{-1} + IC at 40 DAS (PE)	31.17	23.11	16.42	14.89	14.40
Mean	31.74	23.71	17.19	14.21	13.15

Table 2 : Seed. Straw and biological yields as well as harvest index, CUW, WUE and WEE as influenced by irrigation levels and weed management practices (Pooled data of 2006 -07 and 2007-08)

Treatments	Irrigation applied (mm)	CUW (mm)	WUE ($kg\text{-}ha^{-1}\text{-}mm^{-1}$)	WEE ($kg\text{-}ha^{-1}\text{-}mm^{-1}$)	Seed yield ($kg\ ha^{-1}$)	Straw yield ($kg\ ha^{-1}$)
IW/CPE ratio						
0.6	350	306.50	3.55	3.06	1072	2200
0.8	400	344.00	3.94	3.37	1346	2684
1.0	500	409.89	3.63	2.95	1474	2835
S Em.±	-	5.00	0.06	0.04	20.5	39.9
CD (P=0.05)	-	15.41	0.18	0.14	63.0	123.1
Weed management practices						
Weedy check	417	377.20	2.52	2.27	936	1927
Weed free	417	337.71	4.39	3.56	1479	2904
HW at 20 and 40 DAS	417	344.86	4.16	3.45	1434	2835
HW at 20 DAS + IC at	417	357.72	3.60	3.09	1287	2552
Pend@ 0.75 kg ha^{-1}(PE)	417	366.89	3.28	2.90	1199	2380
Pend.@ 0.75 kg ha^{-1} + IC at 40 DAS (PE)	417	336.38	4.30	3.48	1447	2840
SEm.±	-	6.43	0.06	0.05	19.3	40.9
CD (P=0.05)	-	18.06	0.16	0.13	54.2	114.8
Interaction (I x W)	-	NS	NS	NS	Sig.	Sig.

Table 3 : Seed, straw and biological yields (kg ha^{-1}) as influenced by interaction effect between irrigation levels and weed management practices (Pooled data of 2006-07 and 2007-08)1

Weed management practices / IW/CPE ratio	Seed yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Biological yield (kg ha^{-1})		
	0.6	0.8	1.0	0.6	0.8	1.0	0.6	0.8	1.0
Weedy check	861	929	1017	1874	1900	2007	2736	2829	3024
Weed free	1189	1551	1698	2402	3059	3249	3592	4610	4947
HW at 20 and 40 DAS	1164	1494	1645	2363	2979	3164	3526	4473	4809
HW at 20 DAS and IC at AS	1041	1316	1503	2138	2624	2892	3180	3941	4395
Pend@ 0.75 kg ha^{-1}(PE)	996	1284	1318	2046	2560	2534	3042	3844	3852
Pend.@ 0.75 kg ha^{-1} + IC at 40 DAS (PE)	1177	1502	1663	2376	2979	3164	3553	4481	4827
CD (P =0.05)	106.3*		93.9**	219.1*		198.8**	321.5*		288.2**

* CD for irrigation levels means at same level of weed management practices

** CD for weed management practices means at same level of irrigation mean

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