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Effect of drip irrigation and bioregulators on yield, economics and water use of fenugreek (*Trigonella foenum-graecum*)

S R Bhunia[1]*, I M Verma[1], M P Sahu, N C Sharma & K Balai

College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Beechwal, Bikaner-334 006, Rajasthan.
**E-mail: srbhuniarau@gmail.com*

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Abstract

The field experiment was conducted during winter seasons of 2009–10 and 2010–11 to assess the effect of drip irrigation levels and bioregulators (thiourea and Thioglycollic acid) on fenugreek. Increasing levels of drip irrigation from 0.6 to 1.0 ETc enhanced yield attributes *viz*., branches plant^{-1}, pods plant^{-1}, pod length, seeds pod^{-1} and test weight. Increased yield attributes with 1.0 ETc thus, enhanced seed yield (15.53 q ha^{-1}) and stover yield (31.54 q ha^{-1}). However highest B:C ratio (2.11) was recorded with 0.8 ETc irrigation level and highest water use efficiency of 4.83 kg ha^{-1} mm with 0.6 ETc. Recommended surface irrigation treatment recorded 13.02 q ha^{-1} seed yield with using 540 mm of water. Whereas, fenugreek under drip irrigation at 0.6, 0.8 and 1.0 ETc used 278.16, 370.88 and 463.60 mm of water, respectively. Seed treatment of fenugreek before sowing with bio-regulator thiourea (500 ppm) for 4 h recorded higher yield attributes *viz*., pods plant^{-1}, pod length and test weight, as well as, seed yield of 14.85 q ha^{-1} against 14.36 q ha^{-1} where no seed treatment was done. Thus, in turn fetched higher water use efficiency (4.00 kg ha^{-1} mm) and B:C ratio (2.08). Further, foliar spray with 200 ppm thioglycollic acid at vegetative and seed formation stages recorded highest seed yield of 15.01 q ha^{-1} over 100 ppm thioglycollic acid spray (14.59 q ha^{-1}) or no spray treatment (14.21 q ha^{-1}). Increased yield thus enhanced water use efficiency (3.93-4.05 kg ha^{-1} mm) and B:C ratio (2.06-2.11) in thioglycollic acid treated crop.

Keywords: bioregulators, drip irrigation, fenugreek, thioglycollic acid, thiourea, water use efficiency

Introduction

Fenugreek (*Trigonella foenum-graecum*) is predominantly grown in arid and semi arid regions of the Rajasthan. The seeds of fenugreek are used as a condiment and seasoning agent for garnishing and flavouring dishes. Water is an indispensable factor for every metabolic activity of plant and limited quantity of water available for irrigation calls for proper scheduling of irrigation to improve water productivity of fenugreek (Mehta *et al*. 2010). Recent trend of scheduling irrigation on the basis of climatological approach has been considered as most scientific particularly under

[1]Land Scape Cell, Swami Keshwanand Rajasthan Agricultural University, Bikaner-334 006, Rajasthan.

drip system, since it integrates all weather parameters giving them natural weightage in a given climate-plant-continuum (Parihar *et al*. 1976). In arid western Rajasthan, drip irrigation on the basis of climatological approach hold great promise for minimizing water loss and improving its efficiency and ultimately productivity. Sulphydryl (-SH-) compounds improve phloem translocation of photosynthate and crop productivity. Thus, they act as bioregulators and play an important role in improving water use efficiency through enhanced phloem translocation and yield formation particularly in arid regions. Further, pre-conditioning of seeds by soaking in solution of growth regulators is known to improve seeding emergence and vigour (Garg *et al*. 2006). The information on bioregulators, thiourea and thioglycollic acid, and drip irrigation on fenugreek growth and yield are meager. Hence, there is a felt need to generate precise information on irrigation requirement through drip and bio-regulators thiourea and thioglycollic acid in fenugreek.

Materials and methods

The field experiment was conducted during winter (*rabi*) seasons of 2009–10 and 2010–11 at Swami Keshwanand Rajasthan Agricultural University Farm, Bikaner situated in arid North-Western plain zone of Rajasthan. The soil was sandy loam in nature, having field capacity 6.8%, bulk density 1.51 g cc^{-1} pH (1:2) 8.2, electrical conductivity (1:2) 0.2 dS m^{-1}. The soil was very low in organic matter (0.11%) and medium in available P (12.4 kg ha^{-1}) and high in available K (340 kg ha^{-1}). The treatments consist of three irrigation levels (0.6, 0.8 and 1.0 ETc), two bio-regulator thiourea (no seed treatment and seed treatment with 500 ppm thiourea for 4 h before sowing), foliar sprays of bioregulator thioglycollic acid (no spray, 100 ppm spray and 200 ppm spray at vegetative and seed formation stages) and control i.e., absolute control (surface irrigation and no use of bio-regulator). The experiment was laid out in randomized block design and replicated thrice. Recommended dose of 40 kg N ha^{-1} and 16 kg ha^{-1} P was applied as basal at the time of sowing. The crop variety RMt-1 was sown during 1st week of December using 25 kg seed ha^{-1} and harvested in the 4th week of April in both the years. The crop was sown at 20 cm row spacing in a group of 4 lines around drip line and 60 cm spacing between two groups. The drip lines were laid at 120 cm spacing to facilitate easy water availability to each crop row under drip system, as well as, to bring down cost of drip system. Under surface irrigation crop was sown at 30 cm row spacing. No rainfall was received in both the years during crop growing period. Pan evaporation during 2009–10 and 2010–11 was 853.6 and 862.8 mm, respectively.

Results and discussions

Irrigation levels

Increasing irrigation levels from 0.6 to 1.0 ETc under drip increased height and yield attributes *viz*., branches plant^{-1}, pods plant^{-1}, pod length, seeds pod^{-1} and test weight (Table 1). Increased plant height and yield attributes with increasing irrigation levels through drip irrigation thus, enhanced seed yield of

Table 1. Monthwise irrigation events and irrigation water applied (mean of 2 years)

Month	Irrigation events	Pan evaporation (mm)	Drip irrigation (mm)		
			0.6 ETc	0.8 ETc	1.0 ETc
December (1/5-31)	14	79.16	22.97	30.63	38.29
January	16	59.94	27.34	36.45	45.56
February	14	135.79	70.68	94.24	117.80
March	15	214.86	88.37	117.83	147.29
April (1-20)	10	249.23	68.80	91.73	114.66
Total	69	863.60	278.16	370.88	463.60

In surface irrigation, nine irrigations of 60 mm each were applied and total 540 mm water was applied

Table 2. Plant height and yield attributes of fenugreek as influenced by irrigation and bioregulators (pooled of 2 years)

Treatment	Height (cm)	Branch plant^{-1}	Pods plant^{-1}	Pod length(cm)	Seeds pod^{-1}	Test weight (g)
Irrigation level						
0.6 ETc	50.8	6.6	40.4	12.4	15.2	12.3
0.8 ETc	65.3	7.2	44.5	12.6	15.7	12.9
1.0 ETc	66.4	7.3	45.0	12.6	15.7	13.0
Surface irrigation	49.6	6.7	40.3	12.4	15.3	12.3
CD (P<0.05)	1.3	0.5	1.2	NS	NS	0.3
Thiourea						
No seed treatment	60.1	7.0	42.5	12.1	15.1	12.4
Seed treatment (500 ppm)	60.9	7.1	44.1	12.9	15.6	13.0
CD (P<0.05)	N S	NS	1.0	NS	NS	0.2
Thioglycollic acid (TGA)						
No spray	59.8	6.9	42.0	12.0	15.0	12.2
100 ppm spray	60.3	7.5	43.7	12.7	15.7	12.8
200 ppm spray	60.4	7.5	43.9	12.8	15.8	13.2
CD (P<0.05)	NS	0.5	1.2	NS	NS	0.3

fenugreek and highest seed yield of 15.53 q ha^{-1} was recorded at 1.0 ETc against 14.84, 13.44 and 13.02 q ha^{-1} with irrigation at 0.8, 0.6 ETc through drip and surface irrigation, respectively. Yadav *et al*. (2006) also reported higher seed cotton yield (21.1 t ha^{-1}) with drip irrigation at 1.0 ETc compared to 17.0 q ha^{-1} at surface irrigation. Similarly, biological and stover yields also followed the similar trend.

Drip irrigation levels from 0.6 to 1.0 ETc saved water by 261.84 to 76.4 mm over surface irrigation which used 540 mm water. Hence, increased yield coupled with less water use in drip irrigation recorded higher water use efficiency (WUE) of 4.83, 4.00 and 3.35 kg ha^{-1} mm at 0.6, 0.8 and 1.0 ETc, respectively against 2.41 kg ha^{-1} mm in surface irrigation. Higher water use efficiency with lower level of drip irrigation might be due to greater increase in seed production as compare to increase in water use (Mehta *et al*. 2010). Lower water use efficiency in surface irrigation (absolute control) may be due to loss of irrigation water from sandy loam soil through deep percolation resulted in higher water use but lowered seed yield. The benefit of drip irrigation at 0.8 and 1.0 ETc was further evident by higher B:C ratio of 2.11 and 2.09, respectively against 2.08 under surface irrigation. However higher irrigation levels under drip reduced harvest index and highest harvest index of 35.08% was recorded at 0.6 ETc compared to 33.92% and 33.99% with 0.8 and 1.0 ETc, respectively (Table 2). Drip irrigation system saved quite a large amount of water, that can be useful in horizontal expansion of crop area in winter season when mostly irrigated crops are raised in Rajasthan.

Bioregulators

Seed treatment before sowing with 500 ppm thiourea enhanced plant height, branch plant^{-1}, pods plant^{-1} and seed index (Table 2). Increased yield and yield attributes of fenugreek with thiourea treated seed thus attributed to higher seed yield and water use efficiency by 3.41% (14.85 q ha^{-1}) over crop grown with untreated seed (Table 2).

Further, seed treatment with thiourea (500 ppm) also enhanced harvest index by 4.3% over untreated seed. This are due to improved photosynthetic efficiency (Hernandez *et al*. 1983) and phloem translocation of photosynthate from source to sink (Sahu & Singh 1995) in thiourea treated crop. Burman *et al*. (2007) also reported higher seed yield with thiourea treated clusterbean in arid region. The benefit of seed treatment with thiourea was further depicted by higher B:C ratio of 2.08 against 2.06 in control.

Foliar spray of thioglycollic acid (TGA) at vegetative and seed formation stages recorded higher yield attributes *viz*., branches plant^{-1}, pods plant^{-1} and test weight, than control (Table 2). Higher yield attributes in turn improved biological yield, seed yield and highest seed yield (15.01 q ha^{-1}) of fenugreek was recorded with 200 ppm TGA spray followed by 100 ppm TGA (14.59 q ha^{-1}) and control (14.21 q ha^{-1}). Increased seed yield thus improved water use efficiency in TGA sprayed crop. Similarly, 200 ppm TGA foliar spray also recorded higher B:C ratio of 2.11 against 2.06 with 10 ppm NAC and 2.04 with no foliar spray (Table 3).

Irrigation-thiourea interaction

Irrigation × thiourea seed treatment was found significant statistically. Thiourea seed treatment along with drip irrigation at 0.6 ETc improved seed yield by 7.4%. Whereas, thiourea seed treatment gave 3.3% higher seed yield at 0.8. However, thiourea could not influence seed yield at 1.0 ETc. It is thus concluded that under water stress condition thiourea played a role in mitigating adverse effect of water stress. This may be due to improved photo synthesis and phloem translocation of photosynthate from source to sink, which is evident by higher harvest index at lower level of irrigation (0.6 and 0.8 ETc) in thiourea treated crop (Table 4). Thiourea seed treatment increased water use efficiency at suboptimal level of irrigation.

Fenugreek can be grown successfully under arid region of Bikaner under drip system at 0.8 ETc. Yield can be further improved by treating seed with 500 ppm thiourea before sowing. The effect of thiourea is more pronounced under water stress condition (0.6 ETc.)

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