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Yield, economics and water use of fenugreek (*Trigonella foenum-graecum*) as influenced by drip irrigation and bio-regulators

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Abstract

An experiment was conducted during winter season of 2009-10 and 2010-11 to assess the effect of drip irrigation levels and bioregulators thiourea and N-acetyl cysteine on fenugreek (*Trigonella foenum-graecum*) at S.K. Rajasthan Agricultural University Farm, Bikaner. Increasing levels of drip irrigation from 0.6 to 1.0 ETc enhanced yield attributes viz., branch/ plant, pods/ plant, pod length, seeds/ pod and test weight. Increased yield attributes thus, enhanced seed yield (1.61 t/ha) and B:C ratio (1.25) with 1.0 ETc. However, highest water use efficiency (5.06 kg/ ha-mm) was recorded with 0.6 ETc. Recommended surface irrigation treatment recorded 1.42 t/ha seed yield 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 solution) for 4 hours recorded higher seed yield of 1.59 t/ha against 1.47 t/ha where no seed treatment was done. Thus, thiourea seed treatment fetched higher water use efficiency (4.29 kg/ha-mm) and B:C ratio (1.25). Further, foliar spray with 20 ppm N-acetyl cysteine at vegetative and seed formation stages recorded highest seed yield of 1.59 t/ha over 10 ppm N-acetyl cysteine spray (1.53 t/ha) or no spray treatment (1.47 t/ha). Increased yield thus enhanced water use efficiency and B:C ratio.

Key words: *Bioregulators, Thiourea, N- acetyl cysteine, Drip irrigation level, Fenugreek, Harvest index, Seed yield, Water*

Introduction

Arid region of Rajasthan is home to seed spice fenugreek (*Trigonella foenum-graecum*). The seeds of fenugreek are used as 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 drip system, since it integrate all weather parameters giving them natural weightage in a given climate-plant-continuum (Parihar *et a*l., 1976). In arid western Rajasthan, drip irrigation on the basis of climatological approach hold great promise for minimizing water loss and improving its utilization efficiency and yield. Not much attention so far has been focused on improving plant biology, more particularly plant molecular mechanisms, which inherently influence not only acquisition of water and nutrient from the soil but they also govern their transport inside the plants and thus these are efficient in improvement of plant performance and yield formation. 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 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 N-acetyl cysteine and drip irrigation on fenugreek growth and yield are meager. Hence, there is a felt need to generate precise information on irrigation requirement of fenugreek through drip and effect of bio-regulators- thiourea and N-acetyl cysteine on fenugreek.

Materials and methods

The field experiment was conducted during winter (*rabi*) seasons of 2009-10 and 2010-11 at Experimental Farm of Swami Keshwanand Rajasthan Agricultural University, Bikaner situated in arid North-Western plain zone of Rajasthan. The soil was sandy loam in nature, having field capacity 6.5%, permanent wilting point 1.8%, bulk density 1.52 g/cc, pH(1:2) 8.2, electrical conductivity (1:2) 0.2 dS/m. The soil is very low in organic carbon (0.11%) and medium in available P (12.4 kg/ha) and high in available K (340 kg/ha). The treatments consist of three irrigation levels (0.6, 0.8 and 1.0 ETc), two levels of bio-regulator thiourea (no seed treatment and seed treatment with 500 ppm thiourea for 4 hours before sowing), foliar sprays of bioregulator N-acetyl cysteine (no spray, 10 ppm

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	373.85**	68.80	91.73	114.66
Total	69	863.60	278.16	370.88	463.60

*upto last irrigation, ** upto harvesting

Results and discussions

Irrigation levels

Increase in irrigation levels from 0.6 to 1.0 ETc under drip increased height and yield attributes viz., branch/ plant, pods/ plant, pod length, seeds/ pod and finally test weight (Table-2). Increased height and yield attributes with increasing irrigation levels through drip thus, enhanced seed yield of fenugreek and highest seed yield of 1.61 t/ha was recorded at 1.0 ETc against 1.5, 1.40 and 1.42 t/ha with irrigation at 0.8, 0.6 ETc and surface irrigation respectively. Yadav *et al*. (2006) also reported higher seed cotton yield (2.11 t/ha) with drip irrigation at 1.0 ETc compared to 1.70 t/ha at surface irrigation. 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 under drip irrigation recorded higher water use efficiency (WUE) of 5.06, 4.25 and 3.46 at 0.6, 0.8 and 1.0 ETc, respectively. 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). Whereas, lowest water use efficiency of 2.63 was recorded at surface irrigation. It may be due to loss of irrigation water from sandy loam soil through deep percolation resulted in higher irrigation requirement but lowered seed yield under surface irrigation. The benefit of drip irrigation at 0.8 and 1.0 ETc was further evident by higher B:C ratio of 1.23 and 1.25, respectively against 1.01 under surface irrigation. However higher irrigation levels under drip reduced harvest index and highest harvest index of 35.66% was recorded at 0.6 ETc compared to 35.56 and 33.09% with 0.8 and 1.0 ETc, respectively (Table-2). It may be ascribed to enhanced ease in absorbing water in higher levels of irrigation which attributed to luxuriant growth and development but that did not totally translated into seed production.

Table 2. Height and yield attributes of fenugreek as influenced by drip irrigation and bioregulators (mean of 2 years)

Treatment	Height (cm)	Branch/ plant	Pods/ plant	Pod length (cm)	Seeds/pod	Test weight (g)
Irrigation level						
0.6 ETc	46.5	5.5	38.4	9.7	14.2	9.68
0.8 ETc	60.8	8.0	48.5	12.3	15.8	12.98
1.0 ETc	63.4	8.6	50.2	12.3	15.9	13.01
Surface irrigation	46.6	5.6	39.8	9.7	14.2	8.72
CD at 5%	1.5	0.4	2.8	0.5	0.3	0.4
Thiourea						
No seed treatment	55.5	7.1	43.5	10.5	14.8	11.2
Seed treatment (500 ppm)	58.3	7.6	47.9	12.4	15.8	12.6
CD at 5%	1.1	0.3	2.4	0.4	0.2	0.3
N-acytyle cysteine						
No spray	53.4	6.9	44.2	10.5	14.8	10.6
10 ppm spray	57.8	7.5	45.7	11.6	15.4	12.5
20 ppm spray	59.5	7.6	47.2	12.2	15.7	12.6
CD at 5%	1.5	0.3	2.8	0.5	0.3	0.4

Bioregulators

Seed treatment before sowing with 500 ppm thiourea enhanced plant height, branch/ plant, pods/plant, pod length, seed/ pod and seed index (Table 2). Seed treatment with thiourea enhanced seed yield and water use efficiency by 8.6% over crop grown with untreated seed (Table 3). Further, seed treatment with thiourea (500 ppm) enhanced harvest index by 6% over untreated seed. This may be due to thourea induced improved photosynthetic efficiency (Hernandez *et al.*, 1983) and phloem translocation of photosynthate from source to sink (Sahu and Singh, 1995). Burman *et al.*, (2007) also reported higher seed yield of clusterbean when treated with thiourea in arid region. The benefit of seed treatment with thiourea was further depicted by higher B:C ratio of 1.25 against 1.10 in no seed treatment.

Foliar spray of N-acetyl cysteine (NAC) at vegetative and seed formation stages recorded higher yield attributes than no spray treatment (Table 2). Higher yield attributes in turn improved seed yield and highest seed yield

(1.59 t/ha) of fenugreek was recorded with 20 ppm NAC followed by 10 ppm NAC (1.53 t/ha) and no spray treatment (1.47 t/ha). Increased seed yield thus improved water use efficiency with higher doses of NAC spray. Similarly, 20 ppm NAC foliar spray also recorded higher B:C ratio of 1.21 against 1.17 with 10 ppm NAC and 1.13 with no foliar spray (Table 3).

Irrigation-thiourea interaction

Irrigation-thiourea seed treatment interaction was found significant. Thiourea seed treatment along with drip irrigation at 0.6 ETc improved seed yield by 15.7% whereas, thiourea seed treatment gave 7.8 and 3.6% higher seed yield at 0.8 and 1.0 ETc irrigation level, respectively. Thus, thiourea seed treatment increased water use efficiency at every level of irrigation. However magnitude of difference is higher at lower level of irrigation (Table 4). It might be due to alleviation of adverse effect of stress at 0.6 Etc, which improved photosynthetic efficiency and more efficient nitrogen metabolism even under water stress conditions (Garg *et al*., 2006). Further, sulphydryl compound thiourea played a crucial role in enhancing phloem translocation of photosynthate from source to sink, which is evident by higher harvest index at lower level of irrigation (0.6 Etc) in thiourea treated crop (Sahu and Singh, 1995).

Table 3. Effect of irrigation and bioregulators on seed yield, biological yield, water use and benefit : cost ratio of fenugreek (pooled of 2 years)

Treatment	Seed yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	Water use (mm)	Water use efficiency (kg/ha-mm)	B:C ratio
Irrigation level							
0.6 ETc	1.41	2.54	3.95	35.66	278.16	5.06	1.03
0.8 ETc	1.58	2.85	4.43	35.56	370.88	4.25	1.23
1.0 ETc	1.61	3.25	4.85	33.09	463.60	3.46	1.25
Surface irrigation	1.42	2.63	4.06	35.09	540.00	2.63	1.01
CD at 5%	0.01	0.02	0.02	-	-	-	-
Thiourea							
No seed treatment	1.47	2.79	4.31	34.01	370.88	3.95	1.10
Seed treatment (500 ppm)	1.59	2.96	4.36	36.51	370.88	4.29	1.25
CD at 5%	0.01	0.02	0.02	-	-	-	-
N-acytyle cysteine							
No spray	1.47	2.64	4.21	33.55	370.88	3.97	1.13
10 ppm spray	1.53	2.96	4.43	34.48	370.88	4.12	1.17
20 ppm spray	1.59	3.03	4.57	34.71	370.88	4.28	1.21
CD at 5%	0.01	0.02	0.02	-	-	-	-

Table 4. Interaction of bioregulator- thiourea and irrigation on fenugreek (pooled of 2 years)

Treatment	Seed yield (q/ha)	Biological yield (q/ha)	Harvest index (%)	Water use (mm)	Water use efficiency (kg/ha-mm)
Irrigation and thiourea interaction					
0.6 ETc + No thiourea	1.31	3.79	34.47	278.16	4.69
0.6 ETc + thiourea seed treatment	1.51	4.11	36.78	278.16	5.43
0.8 ETc + No thiourea	1.52	4.30	35.24	370.88	4.09
0.8 ETc + thiourea seed treatment	1.63	4.55	35.91	370.88	4.41
1.0 ETc + No thiourea	1.58	4.85	32.54	463.60	3.40
1.0 ETc + thiourea seed treatment	1.63	4.86	48.55	463.60	3.52
CD at 5%	0.01	0.04	-	-	-

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