Study the water requirement of cluster bean under micro sprinkler with nitrogen and irrigation levels

P.A.Gawande[1]; K. P. Giri [2] and A.N.Mankar[3]

[1]Assistant Professor, Department of Agricultural Engineering, Dr. PDKV, Akola, Maharashtra.

[2]Post Graduate Student, Department of Irrigation and Drainage Engineering, Dr. PDKV, Akola, Maharashtra.

[3]Assistant Professor, Department of Agricultural Engineering, Dr. PDKV, Akola, Maharashtra.

ABSTRACT :

A field experiment framed in split plot design was conducted to check response of cluster bean to irrigation and nitrogen levels under micro sprinklerat research farm of All India Co-ordinate Research Project for Dryland Agriculture, Dr. PDKV, Akola during 29 January to 28 May 2015. The experiment comprised of three main treatments of irrigation (I_1,I_2, I_3) and three sub treatments of nitrogen (T_1, T_2, T_3) with four replication. Seasonal water requirement of cluster bean was found to be highest under irrigation level at 1.2 ET_c (I_3) followed by $I_2$and I_1. It was found lowest under irrigation level at 0.8 ET_c with micro sprinkler irrigation. Amongst the irrigation levels, treatment I_3 (1.2 ET_c) was found to be significantly superior over treatment I_2 (1.0 ET_c) and I_1 (0.8 ET_c) in respect growth and yield of cluster bean. Gross returns and benefit cost ratio were higher in I_3 followed by I_2 and I_1. Nitrogen treatments also significantly influenced the growth and yield parameters. Nitrogen level T_3 (30 Kg/ha) recorded significantly highest growth and yield parameters followed by T_2 (25 Kg/ha) and T_1 (20 Kg/ha). Gross returns and benefit cost ratio were highest in treatment T_3 followed by T_2 and T_1. The total irrigation water applied highest in treatment I_3 followed by I_2 and I_1. Irrigation level at I_3 recorded highest water use efficiency.

Keywords:Cluster bean, micro sprinkler, nitrogen, water use efficiency, benefit cost ratio.

Introduction

Cluster bean commonly called as guar (*Cyamopsis tetragonoloba* (L.)Taub) is an important legume vegetable crop belongs to family Leguminosae. In India, cluster bean occupies an area of 5152 hectares with a production of 2461 tonnes. India is considered to be the centre of origin for cluster bean. Green cluster bean pod contains moisture 81.0g, carbohydrates 10.8 g, protein 3.2 g, fat 0.4 g, minerals 1.4 g, thiamine 0.09 mg, riboflavin 0.09 mg, vitamin C 47 mg and vitamin A 316 IU per 100 g of pod. It is a drought tolerant and hardy legume hence its cultivation is being concentrated in the arid and semiarid regions of India, Pakistan and South Africa. In India cultivation of cluster bean is concentrated in the north-west regions comprising Haryana, Punjab, Rajasthan, Uttarpradesh, Gujarat and Maharashtra. It is very common and popular vegetable grown by farmers either as rainfed during kharif and irrigated in summer season.

The traditional surface irrigation methods are required to be replaced by modern water saving more yielding irrigation method like sprinkler, micro sprinkler and trickle. Micro-irrigation systems have been proved to be most useful in saving water and increasing crop yields. It is well documented fact that drip/trickle irrigation saves about 35-50% water and increases yield from 15 to 45% over conventional method of irrigation. Similarly, sprinkler irrigation is also reported to save water and increase yield of

various crops. Micro sprinkler irrigation system, which combines the advantages of both trickle and sprinkler irrigation system. It eliminates certain disadvantages of trickle as well as the conventional sprinkler system of irrigation.

The use of micro sprinkler depending upon situation and availability of water. The cost of initial establishment is lower compared to drip system. Further in summer the sprinkling of water helps in reducing the microclimate temperature and increasing the humidity, thereby improving the growth and yield of the crop. The water saved is to the tune of 20 to 30 per cent.

Material and methods

The experiment was laid out on the experimental farm of All India Co-ordinate Research Project for Dryland Agriculture, during summer season of 2015. The topography of the field was fairly uniform and levelled. Average annual precipitation is 760 mm, out of which approximately 86 per cent is received during June to September.

The climate of the area is semi arid, characterized by three distinct seasons; mainly summer being hot and dry from March to May, the warm and rainy monsoon from June to October and winter with mild cold from November to February. The mean annual maximum and minimum temperature are 48.23°C and 22.05°C in summer and 32.88°C and 14.35°C in winter respectively.

Soil at experimental site

Physical and chemical analysis was carried out of the composite soil sample to know mechanical and chemical composition of the soil at experimental plot. The Soil samples were randomly collected from different locations of the experiment field before the start of the experiment at the depth of 30 cm with the help of auger. Soil samples were tested in the laboratory of Department of Agricultural Chemistry and Soil Science, Dr. PDKV, Akola.Results of these analyses are presented in Table 1 and Table 2.

Table 1 Mechanical properties of soil

Sr. No.	Particulars	Observations	Analytical method used
1	Sand (%)	14.30	Buoyococus Hydrometer Method
2	Silt (%)	47.55	
3	Clay (%)	38.15	
4	Soil texture class	Silty clay loam	

Table 2 Chemical properties of soil

Sr. No.	Particulars	Observations	Analytical method used
1	pH	8.20	pH meter using 1:2.5 soil water ratio
2	EC (dS/m)	0.60	Conductivity bridge from 1:2.5 soil water ratio
3	Available nitrogen (Kg/ha)	285	Alkaline potassium permagnate method

Water source and its quality

The existing source of water was water distribution system of university. The water was conveyed to the field through pipe line. Before start of experiment, water was analyzed for its quality to evaluate different parameter. The result are presented in Table 3

Table 3 Chemical analysis of irrigation water

Sr. No.	Particulars	Observations
1	pH	8.32
2	Ec (dS/m)	1.48

Fertigation

Fertigation is the application of water soluble solid fertilizers or liquid fertilizers. The factors that govern the fertigation are soil type, crop, method of irrigation used. Water quality, type of fertilizers, economic feasibility etc. The right combination of water and nutrient is the key for higher yield and quality of produce. With the fertigation, nutrient use efficiency can be increased also loss of nutrients to the ground water is reduced. Thus, along with saving of water fertilizer, time, labour and energy can alsobe saved substantially.

In this experiment we used soluble fertilizer. The treatments of different nitrogen levels were given through fertigation in five equal splits at 15 days interval after sowing.

Venturi injector

The operation principle of venturi is to create pressure difference in the pipeline which accelerates the water flow and creates suction effect, which is used by pump to suck the fertilizer solution into the main line.

Water requirement of cluster bean

Irrigation water requirements to bring the soil to field capacity

$$d = \left(\frac{Mfc - Mbi}{100}\right) \times As \times Ds$$

Where,

d = Net amount of water to be applied during an irrigation, cm

Mfc = Moisture content at field capacity, per cent

Mbi = Moisture content before irrigation, per cent

As = Apperent specific gravity, g/cc

Ds =Depth of effective rootzone, cm

Quantity of water required per plot in litres was calculated by using equation

Q = d x A

In which,

Q = Quantity of water required per plot, liters

d = Net amount of water to be applied during an irrigation, mm

A = Area of plot, m^2

Irrigation water requirements for treatments based on irrigation scheduling at 1.2 ET_c, 1.0 ET_c and 0.8 ET_c

Q = A x B x C x D

Where,

Q = Water requirement per plant (lit/plant)

A = $ET_o = E_{pan} \times K_p$

B = Crop coefficient (K_C)

C = Canopy factor

D = Area allotted per plant (m^2)

E_{pan} = Cumulative evaporation for two days

K_p = Pan coefficient (0.8)

Estimation of Water Use Efficiency

Water use efficiency is the ratio of crop yield to the amount of irrigation water applied in the field. It was calculated by using equation

$$Eui = \frac{Y}{WR}$$

Where,

Eui - Water use efficiency, $qha^{-1}cm^{-1}$

Y - Crop yield, q

WR - Water requirement, ha-cm

Result and discussion:

Effect of irrigation levels

1. Seasonal water requirement of cluster bean was found to be highest (57.45 lit/plant) under irrigation level at 1.2 ET_c (I_3) followed by I_2 (50.19 lit/plant) and I_1 (42.93 lit /plant).It was found lowest under irrigation level at 0.8 ET (I_1).
2. Irrigation treatments significantly increase growth parameters like plant height, branches per plant, leaf area index. Treatment I_3 (1.2 ET_c) recorded maximum value of all the growth parameters followed by treatment I_2 (1.0 ET_c) and I_1 (0.8 ET_c).

Effect of nitrogen levels

1. Nitrogen treatment T_3 (30 Kg/ha) recorded significantly highest value for all the growth parameters like plant height, branches per plant, leaf area index, days to first and days to 50 per cent flowering followed by T_2 (25 Kg/ha) and T_1 (20 Kg/ha) treatments.
2. Highest water use efficiency was recorded by treatment T_3 (1.83) followed by treatment T_2 (1.81) and T_1 (1.79).

Table 4 : Crop coefficient values of cluster bean

Sr. No.	Growth stages	Crop coefficient
1	Initial stage	0.4
2	Crop development	0.9
3	Mid stage	1.07
4	Late stage	0.8

(Source; Holsambre, WALMI, 1988)

Table 5 : Crop growth stage wise water requirement of cluster bean

Sr. No.	Crop stage	Water applied per plant (lit)		
		I_1	I_2	I_3
1	Common irrigation pre sowing	13.84	13.84	13.84
2	Initial stage	2.5	3.13	3.75
3	Crop development	5.17	6.46	7.75
4	Mid stage	11.56	14.45	17.34
5	Late stage	9.86	12.31	14.77
Total (lit/ plant)		42.93	50.19	57.45

Table 6 : Effect of irrigation and nitrogen levels on plant height (cm), branches per plant and leaf area index

Treatments	Plant height (cm)			Branches per plant			Leaf area index	
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	60 DAS	90 DAS
A. Irrigation levels								
I_1	10.51	39.56	78.62	4.28	12.32	15.60	0.67	0.78
I_2	12.59	41.20	80.79	5.36	14.45	17.44	0.77	0.88
I_3	14.11	43.11	82.56	6.18	16.77	18.82	0.87	0.96
SE(m)±	0.19	0.22	0.31	0.18	0.36	0.50	0.03	0.02
CD at 5%	0.64	0.75	1.08	0.62	1.23	1.73	0.09	0.07
B. Nitrogen levels								
T_1	11.20	40.03	79.48	4.86	13.33	16.16	0.68	0.80
T_2	12.25	41.16	80.54	5.32	14.65	17.45	0.77	0.89
T_3	13.77	42.67	81.25	5.63	15.36	18.25	0.86	0.93
SE(m)±	0.23	0.24	0.25	0.15	0.40	0.36	0.02	0.03
CD at 5%	0.68	0.73	0.76	0.45	1.19	1.08	0.06	0.08
Interaction Effect								
SE(m)±	0.40	0.42	0.44	0.26	0.69	0.63	0.04	0.05
CD at 5%	1.18	1.26	1.31	NS	NS	NS	NS	NS
General Mean	12.40	41.29	80.65	5.28	14.44	17.29	0.77	0.87

Table 7 : Effect of irrigation and nitrogen levels on days to first,days to 50% flowering, cluster per plant, green pod per plant, pod length and weight of green pod per plant

Treatments	Days to first Flowering	Days to 50% flowering	Cluster per plant	Green pod per plant	Pod length (cm)	Weight ofgreen pod per plant (gm)
A. Irrigation levels						
I_1	31.12	41.87	8.62	83.25	8.69	80.58
I_2	32.45	43.48	9.43	95.16	9.25	104.92
I_3	33.78	44.72	10.49	106.51	9.62	133.08
SE(m)±	0.24	0.23	0.17	1.29	0.10	0.55
CD at 5%	0.83	0.80	0.60	4.47	0.36	1.90
B. Nitrogen levels						
T_1	31.97	42.46	9.12	89.97	9.12	89.97
T_2	32.36	43.50	9.56	95.65	9.56	95.65
T_3	33.01	44.11	9.86	99.30	9.86	99.30
SE(m)±	0.11	0.24	0.13	1.67	0.13	1.67
CD at 5%	0.33	0.71	0.39	4.98	0.39	4.98
Interaction Effect						
SE(m)±	0.19	0.41	0.23	2.90	0.23	2.90
CD at 5%	NS	NS	NS	NS	NS	NS
General Mean	32.45	43.36	9.51	94.97	9.51	94.97

Table 8 : Effect of irrigation and nitrogen levels on green pod yield per hectare

Treatments	Green pod yield per hectare (q/ha)
A. Irrigation levels	
I_1	38.29
I_2	50.00
I_3	63.29
SE(m)±	0.50
CD at 5%	1.72
B. Nitrogen levels	
T_1	48.31
T_2	50.61
T_3	52.66
SE(m)±	0.46
CD at 5%	1.37
Interaction Effect	
SE(m)±	0.80
CD at 5%	2.38
General Mean	50.23

Table 9 : Yield, irrigation water applied and water use efficiency as influenced by different treatments

Treatment	Yield of cluster bean (q/ha)	Irrigation water applied (ha-cm)	Water use efficiency (q/ha-cm)
A. Irrigation levels			
I_1	38.29	23.85	1.61
I_2	50.00	27.88	1.79
I_3	63.29	31.92	1.98
B. Nitrogen levels			
T_1	48.31	26.95	1.79
T_2	50.61	27.95	1.81
T_3	52.66	28.76	1.83
GM	50.53	27.89	1.80

Conclusions

1. Irrigation level at 1.2 ET_c (I_3) recorded significantly higher growth and yield parameters of summer cluster bean over I_2 (1.0 ET_c) and I_1 (0.8 ET_c).
2. Nitrogen level of 30 Kg/ha (T_3) recorded significantly superior growth and yield parameter of summer cluster bean over T_2 (25 Kg/ha) and T_1 (20 Kg/ha).
3. The best combination I_3 x T_3 (1.2 ET_c x 30 Kg N/ha) was observed maximum yield per hectare in summer condition.
4. The observations are based on the results of experiment conducted for only one season and therefore these results are suggestive.

Refernces

Ayare BL, Thokal RT, Mane MS, Thorat TN, and Dabke DJ (2012) Effect of micro-irrigation systems and fertilizer levels on growth and yield of green chilli (*Capsicun annum*). International Journal of Agricultural Engineering. 5(2): 220-224.

Kakhandaki SH, Padmakumari O, Madhusudhan MS, and Ramappa KT (2012) Study on cost economics of drip and micro sprinkler irrigation system for tomato. International Journal of Agricultural Engineering. 5(1): 95-97.

Kumar S, Asrey R, Mandal G, and Singh R (2009) Micro sprinkler, drip and furrow irrigation for potato cultivation in semiarid environment. Indian Journal of Agricultural Science. 79(3): 165-169.

Kumar S, Kumar A, and Mandal G (2006) Effect of irrigation scheduling and fertigation on storability of onion (*Allium cepa*) under micro sprinkler irrigation regime. Indian J. Agri. Sci. 76(7): 401-404.

Kumar S, Singh R, Nangare DD, and Gupta RK (2008) Optimization of irrigation for potato with microsprinkler. Journal of Agricultural Engineering.45(3):34–7.

Meranzova R, and Babrikov T (2002) Evapotranspiration of long-day onion, irrigated by micro sprinklers. J. Cent. Eur. Agric. 3: 190-193.

Pandey AK, Singh AK, Kumar A, and Singh SK (2013) Effect of Drip Irrigation, Spacing and Nitrogen Fertigation on Productivity of Chilli (*Capsicum annuum* L.). Environment & Ecology. 31 (1): 139-142.

Rao BK, Chandrashekhararao C, Anuradha M, and Pande VC (2014) Effect of micro sprinkler system on input use efficiency, labour cost andeconomic viability in tobacco (*Nicotiana tabacum* L.) seedling production. Indian Journal of Agricultural Sciences.84(4): 439–43.

Rathore SS, Shekhawat S, Kandpal BK, and Premi OP (2014)Micro-irrigation andfertigation improves gas exchange, productivity traits and economics of Indian mustard (*Brassica juncea* L. Czernj and Cosson) under semi-arid conditions. Australian Journal of Crop Sciences. 8(4):582-595.