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Effect of water and nitrogen levels on yield attributes, water productivity and economics of cluster bean (*Cyamopsis tetragonoloba*) in hot arid region

Rakesh Kumar, N.K. Pareek, V.S. Rathore[1], Vinay Nangiya[2], N.D. Yadava[1], R.S. Yadav **10.18805/LR-4076**

ABSTRACT

A field experiment was conducted at research farm, Agricultural Research Sub-Station, Hanumangarh, Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan during *kharif*, 2016 to study the effect of water and nitrogen levels on yield attributes, water productivity and economics of cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.].Cluster bean variety RGC-1055 with seed rate of 16 kg/ha was planted using 3 levels of irrigation (100, 200 and 300 mm) and 4 level of nitrogen (0, 20, 40 and 60 kg/ha) and analyzed in split plot design with three replication. Results showed that irrigation at 200 mm significantly increased number of pods/plant (44.7), number of seeds/pod (7.8), test weight (28.7g), net returns (Rs 31179/ha) and B:C ratio (2.1) over 100 mm irrigation level. However, water productivity (0.25 kg m^{-3}) was highest at 100 mm irrigation level. Nitrogen level at 40 kg/ha significantly increased number of pods/plant (48.3), number of seeds/pod (8.4), test weight (32.2 g), net returns (Rs. 32273/ha), B:C ratio (2.12) and water productivity (0.27 kg m^{-3}) over no application of N.

Key words: Clusterbean, Irrigation level, Nitrogen, Water productivity.

INTRODUCTION

Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] commonly known as guar, is an important leguminous crop of arid and semi-arid regions (Bhatt *et al.*, 2017 and Rathore *et al.*, 2007a). Clusterbean is a multi-purpose plant, mostly used as a source of galactomannan gum, which is used as a thickener and stabilizer in foods such as salad dressings, ice cream and yoghurt. The gum and the water-soluble resin extracted from the seeds are also used in other industries, including paper manufacturing, cosmetics, mining and oil drilling (Wong *et al*., 1997). Traditionally, it has been grown as rainfed crops. However, during past one decade it has been grown as an irrigated crops in arid and semi-arid regions (Sammauria *et al*., 2009). The information pertaining to effects of irrigation on growth, yield and water productivity of clusterbean is inadequate. Nitrogen plays an important role in plant metabolism, being an essential constituent of several metabolically active compounds. It is a major structural constituent of cell, protein and enzymes and play an important role in growth, yield and quality of clusterbean (Saxena *et al*., 2003). Water productivity, a concept expressing the valueor benefit derived from the use of water, includes various aspects of water management and is very relevant for arid and semi-arid regions (Kumar *et al*., 2016). In addition, the irrigation and nitrogen rate intearct to influence yield, quality and water productivity. The information regarding effects of irrigation and N rates and their interaction on yield and water productivity of cluster bean is scanty. Therefore, the present investigation was undertaken with the objective to assess yield and water productivity of cluster bean under different irrigation and N application rates.

College of Agriculture, Swami Keshwanand Rajasthan Agriculture University, Bikaner-334 006, Rajasthan, India.
[1]Regional Research Station, Central Arid Zone Research Institute, Bikaner-334 004, Rajasthan, India.
[2]Senior Hydrologist, ICARDA, Aleppo, Syria.

Corresponding Author: Rakesh Kumar, College of Agriculture, Swami Keshwanand Rajasthan Agriculture University, Bikaner-334 006, Rajasthan, India. Email: rakeshsarswat58@gmail.com

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MATERIALS AND METHODS

The field experiment was conducted during *kharif* season of 2016-17 at Agricultural Research Sub Station, Hanumangarh, SKRAU, Bikaner, Rajasthan. The soil was silty clay with pH 7.4, having 0.21% organic C, 198.4 kg/ha available N, 34.5 kg/ha available P and 383.6 kg/ha available K. The experiment was laid out in split plot design having three replications with 3 irrigation level (100, 200 and 300 mm) and 4 N level (0, 20, 40 and 60 kg/ha). The clusterbean variety 'RGC-1055' was sown with hand-plough in 45 cm rows spacing on 17 July 2017. The net plot size was 3.6 × 3.5 m. A uniform pre sowing irrigation of 60 mm was applied to all plots. The measeured quantity of irrigation to each plot was applied via a 5 cm PVC pipe fitted with water flow meter (Kranti). The plots receiving 100, 200 and 300 mm irrigation were irrigated at 4 (30, 45, 60 and 75 DAS). The

rate of application of water was 25 mm each irrigation in case of I_{100} treatment. In, I_{200} treatments the rate of application of water was 50 mm each irrigation. In case of I_{300} treatment, the first and second irrigation was of 70 mm, and rest of 2 irrigations of 80 mm. The N was applied in the form of urea as basal at the time of sowing. The phosphorus @ 40 kg P_2O_5/ha through SSP as per recommendation of cluster bean. Five random plants were taken from each plot, excluding the border row, for taking observations on yield attributes. The water productivity was computed by dividing yield by total water used. The total water summing up water from irrigation and rainfall during the entire crop season.

RESULTS AND DISCUSSION

Yield attributes

Effect of irrigation

Yield attributes showed significant improvement due to application of irrigation (Table 1). Application of irrigation showed that progressive increase in irrigation levels increased the number of pods/plant and number of seeds/pod in cluster bean. Irrigation at 200 mm recorded significantly higher number of pods/plant and number of seeds/pod over 100 mm irrigation level. It was 20.48 and 9.86 per cent higher than irrigation at 100 mm. Further increase in irrigation levels did not resulted in significant improvement in number of pods per plant. Irrigation at 300 mm recorded significantly highest test weight over 100 mm irrigation level. The better growth as evident by higher leaf area index and dry matter accumulation with an increase irrigation levels might be responsible for higher yield attributes of clusterbean at higher irrigation levels observed in this study. Bhutia and Sharangi (2018) also reported significant improvement in yield of fenugreek with irrigation.

Effects of N

Yield attributes showed significant improvement due to application of nitrogen (Table 1). The application of nitrogen showed significant and favourable effect on number of pods/plant, number of seeds/pod and test weight. Increasing nitrogen levels up to 40 kg N/ha increased the yield attributes progressively and significantly over the just preceding level. A significant and higher number of pods/plant, number of seeds/pod and test weight was obtained with 40 kg N/ha and it was 49.5, 35.5 and 26.8 per cent higher than over control. Further increase in nitrogen rates did not increased the number of pods/plant, number of seeds/pod and test weight significantly. Improved overall growth and profuse branching due to nitrogen fertilization led to increased net photosynthesis on one hand and greater mobilization of photosynthates towards reproductive structures on the other, might have increased the yield attributes significantly. Similar results were also recorded by Upadhayay and Singh (2016) and Ahmad *et al*. (2018).

Water productivity

Effects of irrigation

The water productivity was decreased with an increase in irrigation levels (Table 2). The application of 100 mm irrigation recorded highest water productivity followed by 200 mm and 300 mm irrigation level. The effect of irrigation levels on water productivity is in contrast to its effects on yield, as yield increased with an increase in irrigation levels. The relatively smaller increase in yield compared to amount of irrigation applied with an increase in irrigation levels is probable explanation of decrease in water productivity at higher irrigation levels observed in present study. The decrease in water productivity with increasing irrigation levels has been reported by Abdulmohsin *et al*., (2018) in mungbean.

Effects of N

The water productivity increased with an increase in nitrogen levels, although the difference between N 40 kg*/*ha and N

Table 1: Effect of irrigation and nitrogen levels on yield attributes of cluster bean.

Treatments	No. of pods/ plant	No. of seeds/ pod	Test weight (gm.)
Irrigation level (mm)			
I_{100}	37.1	7.1	27.7
I_{200}	44.7	7.8	28.7
I_{300}	45.8	8.4	33.8
SEm±	1.02	0.15	1.0
CD (P=0.05)	4.0	0.6	3.9
Nitrogen levels (kg/ha)			
N_0	32.3	6.2	25.4
N_{20}	39.9	7.9	29.2
N_{40}	48.3	8.4	32.2
N_{60}	49.1	8.5	33.3
SEm±	1.0	0.13	0.9
CD (P=0.05)	3.0	0.39	2.6

Table 2: Effect of irrigation and nitrogen levels on total water productivity of clusterbean.

Treatments	Total water productivity kg m^{-3}
Irrigation levels (mm)	
I_{100}	0.29
I_{200}	0.25
I_{300}	0.19
SEm±	0.01
CD (P=0.05)	0.03
Nitrogen levels (kg/ha)	
N_0	0.20
N_{20}	0.24
N_{40}	0.27
N_{60}	0.26
SEm±	0.01
CD (P=0.05)	0.01

Table 3: Effect of irrigation and nitrogen levels on economics of clusterbean.

Treatments	Net returns (`/ha)	B:C ratio
Irrigation levels (mm)		
I_{100}	19982	1.71
I_{200}	31179	2.09
I_{300}	31427	2.08
SEm±	1608	0.06
CD (P=0.05)	6313	0.22
Nitrogen levels (kg/ha)		
N_0	19592	1.71
N_{20}	24728	1.87
N_{40}	32273	2.12
N_{60}	33525	2.15
SEm±	579	0.02
CD (P=0.05)	1721	0.06

60 kg/ha levels were non significant (Table 2). The improved water productivity with an increase in nitrogen fertilization observed in the present study might be attributed to increased leaf area which leads to reduction in evaporation component of evapo-transpiration, smaller increase in evapo-transpiration compared to yield and better utilization of available soil water. The results are confirmed with findings of Rathore *et al*., (2007b), who demonstrated that the addition of nitrogen in nitrogen deficient soil increased water productivity, when water is available.

Economics

Effects of irrigation

Significantly higher net return and B:C ratio was recorded with irrigation at 200 mm in comparison to irrigation at 100 mm (Table 3). The cost involved under this treatment was comparatively lower than its additional income, which led to more returns under this treatment. These results also substantiated by the findings of Senthil *et al*., (2018)

Effects of N

Higher net return and B:C ratio wasregistered with nitrogen level 40 kg/ha (Table 3). The cost involved under this treatment was comparatively lower than its additional income, which led to more returns under this treatment. Rathore *et al*., (2007a) and Singh and Kumar (2016) also recorded the higher net returns and B: C ratio with increasing dose of nitrogen fertilizer.

Combined effect of irrigation levels and nitrogen levels on number of pods/ plant, water productivity and economics of cluster bean

Irrigation along with nitrogen levels significantly influenced the dry matter accumulation at harvest, number of pods/ plant, total water productivity and net return of clusterbean. Irrigation at 200 mm and nitrogen rate @ 40 kg/ha significantly improved these parameters in comparison to all the other parameters. Application of 20 kg N/ha is a blanket recommendation for all the pulse crops in general.

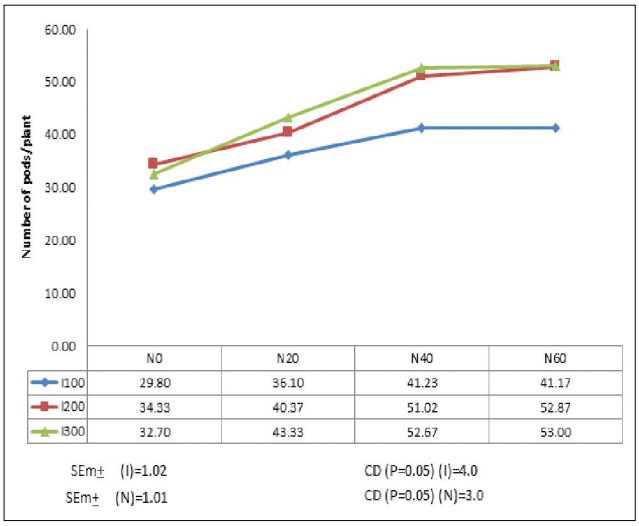

Fig 1: Combined effect of irrigation and nitrogen levels on number of pods/plant of cluster bean.

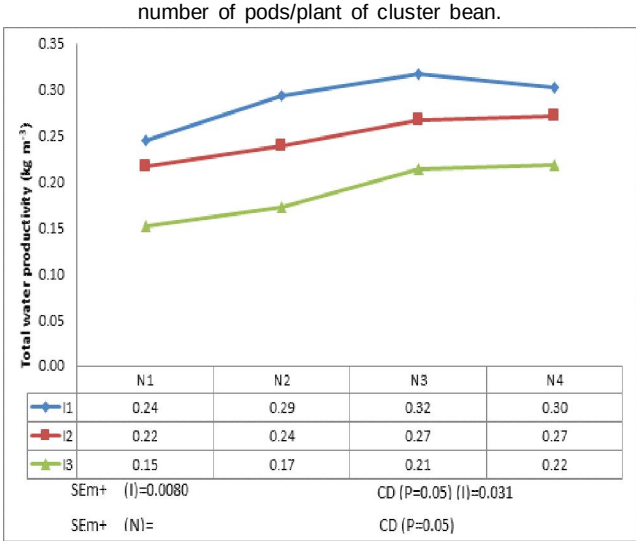

Fig 2: Combined effect of irrigation and nitrogen levels on total water productivity (kg m^{-3}) of cluster bean.

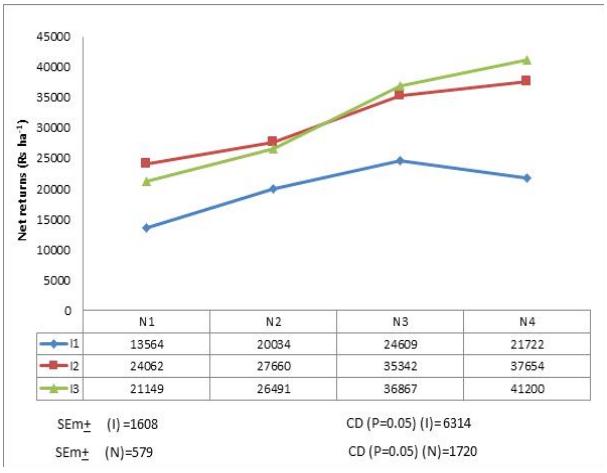

Fig 3: Combined effect of irrigation and nitrogen levels on net returns (`/ha) of cluster bean.

Soils of arid tract of Rajasthan in particular are hungary and thirsty which is evident by the soil nutrient status of the experimental field. Though the legume crops are considered as self sustained crops due to their nitrogen fixing habit, but poor nutrient status in general and nitrogen in particular leads to less nitrogen fixation and poor utilization of this potential of cluster bean as a legume crop. Graded levels of irrigation boosts the crop growth which further increased the nitrogen demand of the crop. Moreover, increased these parameters mentioned in Fig 1, 2 and 3. Supports the present finding of increased performance of cluster bean with higher nitrogen levels and irrigation levels by Ahmad *et al*. (2018).

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