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Influence of irrigation scheduling (IW: CPE ratios) and plant growth regulators on quality, yield and economics of summer clusterbean (*Cyamopsis tetragonoloba* L.) under middle Gujarat conditions

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Abstract
A field experiment was conducted during summer season of the year 2009 at College Agronomy Farm, B. A. college of Agriculture, Anand Agricultural University, Anand Gujarat to study the "Influence of Irrigation scheduling (IW: CPE ratios) and Plant growth regulators on quality, yield and economics of summer clusterbean (*Cyamopsis tetragonoloba* L.) under middle Gujarat conditions". Protein content (%) was influence non significantly with different irrigation schedules and significantly influenced with growth regulators. The highest protein content (29.47%) was recorded under treatment GR_1 (NAA @ 100 ppm at 30 and 60 DAS). Lower protein content (25.86%) was observed under treatment GR_0 (control-water spray). Fiber content was non significantly influenced by different irrigation schedules fibre content significantly influenced due to different plant growth regulators. Maximum (19.20%) and Minimum (15.37%) fibre content were observed under treatment I_3 (1.0 IW: CPE ratio) and I_0 (control), respectively. Significantly highest green pod yield (19480.00 Kg/ha) and green fodder yield (27817.00 Kg/ha) were observed under irrigation treatment of 1.0 IW: CPE ratio (I_3) and also significantly the highest green pod yield (18854 Kg/ha) was secured under treatment GR_1 (NAA @ 100 ppm at 30 and 60 DAS). The lowest green pod yield and fodder yield were observed control treatment of both application of different irrigation schedules and plant growth regulators. The highest gross realization (Rs. 1,97,581/ha) and net realization (Rs,1,78,749/ha) was secured under treatment I_3 (1.0 IW: CPE ratio), followed by treatment I_2 (0.8 IW: CPE ratio) with Rs. 1,88,440/ha and Rs,1,70,765 gross realization and net realization, respectively. The lowest gross realization (Rs.1,65,801/ha) and net realization (Rs,1,51,573/ha) was observed under treatment I_0 (Control- Irrigation at critical growth stages). The highest gross realization(Rs.1,91,043/ha) and net realization (Rs,1,78,743/ha) was observed under treatment GR_1 (NAA @ 100 ppm at 30 and 60 DAS) followed by treatment GR_2 (GA_3 @ 40 ppm at 30 and 60 DAS) with gross realization (Rs.1,83,557/ha) and net realization (Rs. 1,64624/ha).Treatment GR_0 (Control -water spray) recorded the lowest Rs.1,66,105/ha and Rs.1.54,507/ha gross realization and net realization respectively.

Keywords: Irrigation scheduling (IW: CPE ratios), Plant growth regulators, Quality, Yield and Economics of summer clusterbean

Introduction
Clusterbean is an important vegetable crop locally known as "Guar". The name is derived from Sanskrit word "Gau" ahar. Gillete (1958) [4] pointed out "Tropical Africa" as its centre of origin. Botanically clusterbean is cymposis tetragonoloba (L.) Taub. The vegetable are considered as protective supplementary food as they contain large quantities of minerals, vitamins, which are required for normal functioning of human metabolic processes. The important minerals, calcium, phosphorus and iron, which are generally lacking in the cereals, are available in abundant quantities in the vegetables. Among vegetable crops, the crops which belong to 'Leguminosae' family are rich source to others. The cultivated area under clusterbean in India is 20 lakh hectares with production of 6 lakh tones of culsterbean seed with 300kg /ha of average productivity. Rajasthan, Gujarat, Haryana, Uttar Pradesh and Punjab are leading states for cultivation of clusterbean. Gujarat state occupies an area of about of 2,90,147 hectares with production of 2,06,649 metric tones with 750kg\ha average productivity.

Clusterbean pods are quite nutritious vegetable which contain moisture 82.5%, protein 3.7%, fat 0.2%, fibre2-3%, carbohydrate 9.9%, mineral matter 1.4%, calcium 0.13%, phosphorus 0.25%, iron 5.8 mg/100gm and vitamins 49 mg/100 gm. The clusterbean pods are quite nutritious as the protein content in the pod wall at different stages of growth varies from 10.75 to 17.94%, whereas, in seed it ranges from 25.50 to 32.63% (Patel *et al*., 2007) [11]. Clusterbean is known for its ability to restore soil fertility but inadequate attention has been paid to increase its potential although its yield potential is limited. When promising genotypes with higher yield potential are identified, it is necessary to establish their appropriate agronomic manipulation for obtaining higher yield. The various production factors viz. spacing, seed rate, sowing time, dose of fertilizers, methods and time of fertilizer application, irrigation, use of plant growth regulator etc. play an important role in the maximization of green pod of clusterbean production per unit area. Among the various factors of production, irrigation schedules (IW: CPE ratio) and use of different growth regulators play pivotal role in increasing the clusterbean production.

Materials and method

A field experiment was conducted during summer season of the year 2009 at College Agronomy Farm, B. A. college of Agriculture, Anand Agricultural University, Anand Gujarat to study the "Influence of Irrigation scheduling (IW: CPE ratios) and Plant growth regulators on quality, yield and economics of summer clusterbean (*Cyamopsis tetragonoloba L.)* under middle Gujarat conditions". Sixteen treatment combinations consisting of four levels of irrigation schedules (IW: CPE ratios) viz., I_0 – Control- Critical growth stages, I_1 – 0.6 IW: CPE ratio, I_2 – 0.8 IW: CPE ratio, I_3 – 1.0 IW: CPE ratio as a main plot treatments and four plant growth regulators viz., GR_0 – Control- water spray, GR_1 – NAA @ 100 ppm at 30 and 60 DAS, GR_2 – GA_3 @ 40 ppm at 30 and 60 DAS, and GR_3 - AA @ 25 ppm at 30 and 60 DAS were relegated in sub plot as sub plot treatments tested under split plot design with four replications. Each experimental unit had 2.70 m X 5.00 m gross plot and 1.50 m X 4.00 m net plot. The cluster bean crop variety *Pusa Navbahar* was sown with prior treatment with *Rhizobium* culture 'pv movable' @ 400 gm/20 kg seeds. It was dry sown at 30 cm row to row and 10 cm plant to plant distance. As sowing was performed under dry condition and the seeds were covered with the soil by manually. The crop was fertilized with 20 kg N and 40 kg P_2O_5 per hectare from DAP and urea as basal application. Experimental soil was loamy sand and initial pH, organic carbon, total nitrogen, available phosphorus and available potassium content were 7.7 and 0.43%, 0.033%, 21.9 kg P/ha and 285.9 kg K/ha, respectively. The weather conditions were favourable for normal crop growth of summer clusterbean during the crop season. The different irrigation treatments (IW: CPE ratios) were imposed after establishment of the crop with the help of 7.5 parshall flume. The application of different plant growth regulators were sprayed as per treatment. The periodical observations on different quality, yield economics parameters were recorded. The protein and fibre content in green pod were also determined.

Protein content in green pod of custerbean was worked out by multiplying the N content of pod with a factor 6.24. The concentration of N was determined through a modified Kjeldahl's procedure (Jackson, 1973) [5]. Fiber content (%) was determined by the oxidative hydrolytic degradation method of Maynard (1970) [7]. First green pod was picked from border row plants and then after total green pods from net plot were plucked up and weighed and average green pod yield was worked out on hectare basis and recorded. After all five picking of the green pod yield data were sumuped and made total green pod yield. Green fodder yield was determined by harvesting of all plants from net plot area then by these data average green fodder yield was worked out on hectare basis and recorded.

Economics: Cost of cultivation of the crop for individual treatment was worked out taking into considering the cost of all the cultivation operations starting from preparatory tillage to harvesting of the crop including the cost of all the inputs. The gross realization and net realization in terms of Rs/ha was worked out taking the present market value of green pod and green fodder obtained for each treatment. The net realization was worked out by subtracting the total cost of production of realization of treatment and recorded accordingly.

Net realization (Rs/ha) = Gross realization - Total cost of production

Statistical analysis: The data generated on quality, yield and economics were subjected to statistical analysis using "Analysis of variance technique". The value of table 'F' at 5% level of significance, where the treatment differences were found significant the value of CD was worked out to compare the treatment mean (Snedecor and Cochran, 1967) [15].

Results and discussion

Protein content (%): The data on protein content (%) indicated that the influence of different irrigation schedules was non significant. The similar result is reported by Prajapati *et al* (2007) [12] and Patel (2008) [9]. Protein content was significantly affected due to application of plant growth regulators. The results indicated that significantly higher protein content (29.47%) was noticed under treatment GR_1 (NAA @ 100 ppm at 30 and 60 DAS) (Table-1). The increase in protein content might be due to check in the elongation of the shoots along with increase in chlorophyll content which resulted in to reduction of consumption of photosynthates for vegetative growth. Another reason for improving protein content is growth regulators both naturally occurring and synthetic chemicals acts at the gene level influencing the transcriptional and mechanism of protein biosynthesis. Significantly the lower protein content (25.86%) was observed under treatment GR_0 (control-water spray). The interaction effect between irrigation schedules and plant growth regulators on protein content was non-significant. The similar findings was reported by Bai *et al* (1987) [1], Bora and Sharma (2003) [3] and Prajapati *et al* (2007) [12].

Fibre content (%): Fibre content (%) of summer clusterbean was significantly influenced due to irrigation schedules. Treatment I_0 (control) recorded minimum fibre content (15.37). The probable reason for that the minimum fibre in the treatment I_0 was under soil moisture stress condition. Maximum fibre content (19.20%) were observed under treatment I_3 (1.0 IW: CPE ratio) and it might be due to increasing soil moisture which favoured the luxurious plant growth for pod and higher fibre content in under I_3 treatment. Fibre content (%) summer clusterbean was significantly influenced due to plant growth regulators and minimum (16.91%) and maximum (18.33%) fibre content were observed under treatment control and GR_1(NAA @ 100 ppm

at 30 and 60 DAS), respectively (Table-1). The interaction effect between irrigation schedules and plant growth regulators on fibre content was non-significant.

Green pod yield: The data pertaining to green pod yield indicated that, significantly influenced due to different irrigation schedules. Treatment I_3 (1.0 IW: CPE ratio) recorded significantly the highest green pod yield (19480 kg/ha). The increase in green pod yield to treatments I_3 (1.0 IW: CPE ratio) was to the tune of 16.04, 12.90 and 4.61 per cent over treatments I_0 (control), I_1 (0.6 IW: CPE ratio) and I_2 (0.8 IW: CPE ratio). The increase in green pod yield might be due to increase in irrigation frequency and consumptive use because of increased ratio. Thus, there was progressive increase in green pod yield due to favourable moisture condition and better availability of soil moisture at higher frequency of irrigation throughout the growth period, which remarkably stimulated finally the green pod yield. The lower number of green pod was obtained because of unsaturated soil moisture environment; a vapour gap would be formed around the roots by their turgor pressure under water stress. This situation avoids soil moisture stress and thus, provided very favourable conditions for soil moisture and nutrient availability such a gap if ever present would reduced the availability of nutrient to the roots probably due to lesser contact between roots and water particle causing drastic reduction in dry matter production and uptake of nutrients. That is why it clearly indicated that crop required frequent water supply for optimum plant growth and high productivity during summer season. The results are in arrangement with Bhadoria and Bhadoria (2002) [2], Prajapati *et al* (2007) [12] and Patel *et al* (2005) [10].

The data regarding the green pod yield indicated that, they were significantly influenced by different plant growth regulator treatments. GR_1 (NAA @ 100 ppm at 30 and 60 DAS) recorded significantly the highest green pod yield (18854 kg/ha). The percent increase in green pod yield by treatment GR_1 (NAA @ 100 ppm at 30 and 60 DAS) was to the tune of 13.22 4.16 and 3.99 per cent over treatment GR_2 (GA_3 @ 40 ppm at 30 and 60 DAS), GR_3 (AA @ 25 ppm at 30 and 60 DAS) and GR_0 (control-water spray), respectively (Table-2). The maximum green pod yield was recorded due to making the plants photosyntheticaly more effective and also preventing flower shading, improving pod setting and consequently increasing the green pod yield. Another reason for maximum green pod yield might be induced larger number of new sinks leading to the greater activity of carboxylating enzymes and rate of protein synthesis, which resulted in to higher photosynthetic rate, translocation and accumulation of metabolites in the sink and eventually greater green pod yield per unit area. The lower green pod yield was recorded under treatment GR_0 (control-water spray, 16360 kg/ha). The results are in agreement with the findings of Bai *et al* (1987) [1], Upadhyay (2002) [16], Pandey *et al* (2004) [8] Prajapati *et al* (2007) [12] and Patel (2008) [9].

Green fodder yield: Application of different irrigation schedules, treatment I_3 (1.0 IW: CPE ratio) produced maximum green fodder yield (27817 kg/ha). The increase in green fodder yield under treatment I_3 (1.0 IW: CPE ratio) was at the extent of 21.39, 13.47 and 5.75 per cent over treatments, I_0 (control), I_1 (0.6 IW: CPE ratio) and I_2 (0.8 IW: CPE ratio), respectively (Table -2). This could be attributed to increase frequency of irrigation and consumptive use of water under treatment I_3 (1.0 IW: CPE ratio). The remarkable increase in the green fodder yield was mainly due to adequate moisture supply throughout the entire crop growth period, which resulted in to better growth and development. Significantly lower green fodder yield (22915 kg/ha) recorded under treatment I_0 (control). Lower green fodder yield with limited water supply was explained based on interval water status in relation to different physiological processes taking place in the plant. These results are in confirmly with those reported by Kher *et al* (1994) [6] and Patel (2008) [9]. Green fodder yield of summer clusterbean was non-significantly influenced due to application of different plant growth regulators. Among different plant growth regulator, treatments GR_3 (GA_3 @ 40 ppm at 30 and 60 DAS) recorded maximum green fodder yield (25883 kg/ha).

Economics: Highest gross realization (Rs. 1,97,581/ha) and net realization (Rs,1,78,749/ha) was secured under treatment I_3 (1.0 IW: CPE ratio), followed by treatment I_2 (0.8 IW: CPE ratio) with Rs. 1,88,440/ha and Rs,1,70,765 gross realization and net realization respectively. The lowest gross realization (Rs.1,65,801/ha) and net realization (Rs,1,51,573/ha) was observed under treatment I_0 (Control- Irrigation at critical growth stages). The results is confirmed the finding of Patel *et al* (2005) [10] and Rana *et al* (2005) [13]. The data pertaining to economics (Table-2), results revealed that the highest gross realization (Rs.1,91,043/ha) and net realization (Rs,1,78,743/ha) was observed under treatment GR_1 (NAA @ 100 ppm at 30 and 60 DAS) followed by treatment GR_2 (GA_3 @ 40 ppm at 30 and 60 DAS) with gross realization (Rs.1,83,557/ha) and net realization (Rs. 1,64624/ha).Treatment GR_0 (Control -water spray) recorded the lowest Rs.1,66,105/ha and Rs.1.54,507/ha gross realization and net realization respectively. The results is confirmed the finding of Patel *et al* (2005) [10].

Conclusion: Protein content (%) was influence non significantly with different irrigation schedules and significantly influenced with growth regulators. Fiber content was non significantly influenced by different irrigation schedules fibre content significantly influenced due to different plant growth regulators. For securing higher green pod yield, gross realization and net realization from summer clusterbean crop cv. "Pusa Navbhar" raised on loamy sand soils of middle Gujarat conditions, it is advisable to apply ten irrigations, including common light irrigation of 25 mm depth applied immediately after dry sowing, and the rest of irrigations, each of 50 mm depth to be scheduled an IW: CPE ratio of 1.0. The first irrigation should be applied at 12 days after sowing for uniform plant stand, second at 10 days after first irrigation and remaining irrigations at an interval of 5 to 8 days with an application of plant growth regulator NAA @ 100 ppm at 30 and 60 DAS.

Table 1: Protein and fibre content (%) of summer clusterbean as influenced by different irrigation schedules and plant growth regulators

Treatments	Protein content (%)	Fibre content (%)
A. Main plot treatment -Irrigation (I): IW: CPE ratio (4 levels)		
I_0 : Control (Irrigation at critical growth stages)	25.57	15.37
I_1 : 0.6 IW: CPE ratio	27.78	18.15
I_2 : 0.8 IW: CPE ratio	28.52	18.28
I_3 : 1.0 IW: CPE ratio	29.76	19.20
S Em ±	1.01	0.49
C D (P = 0.05)	NS	1.56
Sub plot treatment- Plant growth regulators (GR) (4 levels)		
GR_0 : Control (Water spray)	25.86	16.91
GR_1 : NAA @ 100 ppm at 30 & 60 DAS	29.47	18.33
GR_2 : GA_3 @ 40 ppm at 30 & 60 DAS	28.57	17.97
GR_3 : AA @ 25 ppm at 30 & 60 DAS	27.73	17.79
S Em ±	0.87	0.35
C D (P = 0.05)	2.49	0.99
C. Interaction (I x GR)		
I X GR	NS	NS
C V %	12.44	7.79

Table 2: Yield and Economics of different irrigation schedules and plant growth regulators

Treatment	Green pod yield (Kg/ha)	Green fodder yield (Kg/ha)	Gross realization (Rs/ha)	Total cost of production (Rs/ha)	Net Realization (Rs/ha)
A.Irrigation schedules					
I_0 Control: (critical growth stages)	16355	22295	165801	14228	151573
I_1 : 0.6 IW: CPE ratio	16966	24513	172111	16201	155910
I_2 : 0.8 IW: CPE ratio	18581	26304	188440	18175	170765
I_3 : 1.0 IW: CPE ratio	19480	27817	197581	18832	178749
S Em ±	675.4	939.38	-	-	-
C D (P = 0.05)	2160.8	3005.25	-	-	-
B. Plant Growth regulators					
GR_0 : Control (Water spray)	16360	25056	166105	11598	154507
GR_1 : NAA @ 100 ppm at 30 & 60 DAS	18854	25038	191043	12300	178743
GR_2 : GA_3 @ 40 ppm at 30 & 60 DAS	18100	25571	183557	18933	164624
GR_3 : AA @ 25 ppm at 30 & 60 DAS	18068	25883	183268	11922	171346
S Em ±	518.2	802.76	-	-	-
C D (P = 0.05)	1486.3	NS	-	-	-

Sale price: Green pod – 10.00 Rs./Kg, Green fodder – 0.10Rs/Kg

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