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Effect of irrigation based on IW/CPE ratio and sulphur levels on yield and quality of gram (*Cicer arietinum* L.)

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ABSTRACT

A field experiment was carried out during *rabi* 2010-11 to study the growth, yield and quality of gram as influenced by irrigation and sulphur levels. Irrigation and sulphur have shown significant influence on growth, yield, quality, moisture extraction pattern and water use efficiency. Among four irrigation schedules, irrigation scheduled at 0.9 IW/CPE ratio recorded higher values for all the growth parameters at various stages, yield attributes, grain and stover yield, quality parameters as well as net return and BCR while, 0.7 IW/CPE ratio remained on par. Amount of moisture extracted from surface layers was more irrespective of irrigation treatment. Depletion of soil moisture increased and water use efficiency decreased with increasing frequency of irrigation. Application of 40 kg S ha^{-1} recorded higher grain yield, protein content and protein yield, net return and BCR and remained on par with 20 kg S ha^{-1}. However interaction between sulphur and irrigation levels, 20 kg S ha^{-1} and 0.7 IW/CPE has reported higher seed yield, net returns and BCR.

Key words: BCR, Gram, Irrigation, IW/CPE ratio, Sulphur, Water use efficiency.

INTRODUCTION

Gram (*Cicer arietinum* L.) is the most important pulse crop of India accounting 34.6% area and 48.4% production of total pulses with a productivity of 841 kg ha^{-1}. Gujarat occupied 2.46% of gram area and 2.80% of production of the country, respectively with an average productivity of 977 kg ha^{-1}. Since many years farmers were following the same irrigation schedule irrespective of the varieties cultivated without knowing its feasibility under today's climatic conditions. Hence, today's limited water resources along with changing cropping patterns calls for urgent need for application of water at an appropriate intervals for ensuring better water use efficiency. Inspite of this, recent studies on soil fertility across the country reported sulphur deficiency in most of the states including Saurashtra region of Gujarat and further, sulphur was known to increase yield and quality in gram. Precise information regarding appropriate irrigation interval and suitable sulphur dose for gram crop in recent years is very limited in Saurashtra region thus, the present investigation was carried out.

MATERIALS AND METHODS

The field experiment on yield and quality of gram as influenced by irrigation and sulphur levels was conducted at the Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during *rabi* 2010-11. The soil was clayey in texture, slightly alkaline (pH-7.9) in reaction, rich in organic carbon with 0.76%, low in available nitrogen (178.75 kg ha^{-1}), K_2O (112.90 kg ha^{-1}) and sulphur (8.15 ppm) and medium in available P_2O_5 (38.40 kg ha^{-1}). The bulk density of the soil is 1.36 Mg m^{-3} with field capacity 28.4% and permanent wilting point 12.8%. Further, no rainfall was received throughout the crop period.

The experiment was laid out in split plot design comprising four levels of irrigation based on IW/CPE ratios [I_1=0.5, I_2=0.7, I_3=0.9 and I_4=farmer's practice (1st irrigation immediately after sowing, 2nd irrigation at 10-12 DAS and rest of three at an interval of 18-20 days)] as main plot and three levels of sulphur (S_1=0, S_2=20 and S_3=40 kg S ha^{-1}) as sub plot treatments replicating thrice in 36 plots each of size 5.0 m X 3.6 m. Sowing of gram (JG-16) using 60 kg seed ha^{-1} was done at a spacing of 45 cm X 10 cm. One intercultivation followed by a hand weeding was done at 40 DAS. Immediately after sowing and at 12 DAS light irrigations of 50mm depth were given for proper germination and ensuring better establishment of the crop irrespective of cumulative pan evaporation readings. Afterwards irrigation of 50 mm depth was provided as per treatments based on

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cumulative pan evaporation readings. Amount of water to be irrigated was measured using parshall flume of 7.5 mm throat placed at the head irrigation channel. After initial two common irrigations, a total of three (41, 62 and 82 DAS), four (33, 50, 65 and 79 DAS), five (29, 44, 54, 66 and 77 DAS) and three (29, 47 and 68 DAS) irrigations were received by I_1, I_2, I_3 and I_4 treatments, respectively. The quantity of water received by I_1, I_2, I_3 and I_4 treatments is 250mm, 300mm, 350mm and 250mm, respectively. Sulphur was applied in soil as per treatments 10 days prior to sowing in elemental form. Recommended dose of both nitrogen (25 kg ha^{-1}) and phosphorus (50 kg ha^{-1}) was supplied through Urea and DAP, respectively at the time of sowing.

RESULTS AND DISCUSSION

Growth parameters: Giving five irrigations to gram (after initial two common irrigations) at an IW/CPE ratio of 0.9 resulted in significantly higher plant height, plant spread and dry matter accumulation at 60 DAS and at harvest, branches per plant, nodules and nodule dry weight per plant and was at par with 0.7 IW/CPE ratio (Table.1). This was due to the adequate availability of moisture at all critical stages of growth and development contributing to luxurious uptake of nutrients, favourable physiological processes and active cell division. The results obtained by Dixit *et al*. (1993a) are in corroborative with the above results. Further, irrigation at 0.9 IW/CPE ratio delayed the flowering and maturity due to prolonged vegetative growth compared to farmer's practice.

Application of 20 kg S ha^{-1} recorded significantly higher plant height at harvest, higher plant spread and dry matter accumulation at 60 DAS being at par with 40 kg S ha^{-1}. But plant height at 60 DAS, plant spread and dry matter accumulation at harvest, number of nodules and nodule dry weight per plant were significantly higher with the application of 40 kg S ha^{-1} which was at par with 20 kg S ha^{-1} (Table.1). Increase in growth parameters with increased levels of sulphur may be due to its higher availability and uptake as well as its active involvement in synthesis of amino acids, regulation of various metabolic and enzymatic processes along with enhanced nitrogen fixation. Singh *et al*. (2004) reported the similar results.

Yield attributes: Scheduling irrigation to gram at 0.9 IW/CPE ratio recorded significantly maximum number of pods per plant, seeds per pod, test weight, grain and stover yield per plant followed by 0.7 IW/CPE ratio (Table.1&2). The irrigation intervals at 0.9 IW/CPE ratio were nearly coincided with that of farmer's practice and further provided two more irrigations one at peak vegetative stage and another at maturity stage. Thus it may provide higher vegetative growth and synthesis of more photosynthates coupled with better translocation and partitioning from source to sink resulting in more number of well filled pods with more number of seeds. This finally resulted in higher grain and stover yield per plant as well as test weight. These results are in close conformity with Reddy and Ahlawat (1998). Significantly maximum values in test weight, grain and stover yield per plant were recorded with 20 kg S ha^{-1} followed by 40 kg S ha^{-1} (Table.1&2). Influence of sulphur on yield attributes was due to it's vital role in improving the vegetative structures and strong sink strength through the development of reproductive structures as well as production of assimilates to fill economically important sink (Ashok Kumar *et al*., 2006).

Yield: The extent of increase in grain and stover yields of gram at 0.9 IW/CPE ratio was to the tune of 16.88 and 30.68% over farmer's practice, respectively. And it remained at par with 0.7 IW/CPE ratio. The potential increase in grain and stover yields with increasing frequency of irrigation was due to contribution of growth and yield attributes to the yields. These results are in complete agreement with those obtained by Chandrasekhar and Saraf (2005).

Table 1: Effect of irrigation and sulphur levels on growth and yield parameters of gram

Treatments	Plant height (cm) at		Plant spread (cm)		Branches/ plant	Dry matter accumulation (g)		Days to 50% flowering	Days to maturity	Nodules / plant	Nodule dry weight/ plant (g)	No. of pods/ plant	No. of seeds/ pod
	60 DAS	Harvest	60 DAS	Harvest		60 DAS	Harvest						
Irrigation: (IW/CPE ratios)													
I_1: 0.5	29.6	33.5	26.5	18.8	6.4	3.7	14.8	52.8	86.4	20.8	0.197	53.1	1.27
I_2: 0.7	32.3	38.2	30.3	22.8	7.1	5.3	19.7	55.4	93.3	26.6	0.303	58.4	1.25
I_3: 0.9	34.0	42.2	32.1	23.4	7.9	5.7	20.9	57.4	95.9	31.1	0.342	61.0	1.37
I_4: Farmer's practice	31.5	34.7	29.8	18.5	7.4	4.2	16.3	50.9	85.8	22.9	0.214	54.9	1.19
S.Em.±	0.84	1.02	1.05	0.94	0.28	0.21	0.88	0.15	0.23	1.23	0.015	1.34	0.03
C.D. at 5%	2.91	3.53	3.62	3.24	0.97	0.73	3.06	0.51	0.81	4.25	0.053	4.63	0.10
Sulphur levels (kg ha^{-1})													
S_1: 0	30.9	35.7	28.6	19.63	6.6	4.2	16.7	54.2	90.3	22.6	0.244	52.5	1.26
S_2: 20	32.1	38.3	30.3	21.45	7.4	5.0	18.2	54.0	90.5	25.2	0.263	58.0	1.29
S_3: 40	32.5	37.5	30.1	21.52	7.7	5.0	18.8	54.3	90.3	28.3	0.286	60.1	1.25
S.Em.±	0.50	0.61	0.36	0.42	0.24	0.16	0.51	0.25	0.26	0.91	0.009	0.93	0.02
C.D. at 5%	NS	1.84	1.09	1.25	0.71	0.50	1.52	NS	NS	2.74	0.028	2.79	NS
Interaction (I X S)													
S.Em.±	1.00	1.23	0.73	0.84	0.48	0.34	1.02	0.51	0.53	1.83	0.019	1.86	0.04
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	5.48	NS	5.57	NS

Table 2: Effect of irrigation and sulphur levels on yield parameters and yield, quality, water use and production economics of gram

Treatments	Yield parameters			Yield		Harvest index (%)	Quality of grain		Water use		Production economics		
	Test weight (g)	Grain yield/ Plant(g)	Stover yield/ plant(g)	Grain yield/ha (kg)	Stover yield/ha (kg)		Protein content (%)	Protein yield (kg/ha)	CUW* (mm)	WUE** (kg ha^{-1}mm^{-1})	Gross realization (₹/ha)	Net realization (₹/ha	BCR
Irrigation: (IW/CPE ratios)													
I_1: 0.5	17.05	9.2	13.8	1744	2503	41.28	18.80	326	211	6.98	40241	14483	1.56
I_2: 0.7	17.74	11.8	17.5	2199	3472	38.69	20.57	455	248	7.33	50866	24826	1.95
I_3: 0.9	19.03	13.2	18.7	2243	3791	37.27	22.10	496	282	6.41	51984	25661	1.97
I_4: Farmer's practice	16.45	10.4	15.4	1919	2901	40.02	20.58	396	224	7.67	44338	18580	1.72
S.Em.±	0.28	0.47	0.86	103.20	209.47	1.24	0.28	20.94	6.26	0.41			
C.D. at 5%	0.95	1.64	2.97	357.15	724.88	NS	0.98	72.48	21.66	NS			
Sulphur levels (kg ha^{-1})													
S_1: 0	16.62	9.4	15.6	1919	2965	39.65	19.46	374	238	6.75	44364	19349	1.77
S_2: 20	18.65	12.6	17.1	2035	3291	38.28	20.92	429	239	7.10	47104	21134	1.81
S_3: 40	17.44	11.4	16.4	2124	3245	40.00	21.16	451	246	7.44	49088	22165	1.82
S.Em.±	0.18	0.32	0.31	46	71	1.0	0.23	11	6.76	0.16			
C.D. at 5%	0.53	0.95	0.94	137	212	NS	0.70	32	NS	0.49			
Interaction (I X S)													
S.Em.±	0.35	0.63	0.62	91.51	141.74	1.62	0.47	21.67	13.52	0.32			
C.D. at 5%	1.05	1.90	NS	274.37	NS	NS	1.40	64.96	NS	0.97			

*CUE – Consumptive use of water **WUE – Water use efficiency

Sulphur @ 40 kg ha^{-1} recorded significantly higher grain yield and was at par with 20 kg S ha^{-1}. Whereas, maximum stover yield was obtained with 20 kg S ha^{-1} and was at par with 40 kg S ha^{-1}. This potential increase of grain and stover yields with the application of sulphur might be due to it's key role in photosynthetic rate and translocation as well as transformation of assimilates into yields. Shrikrishna *et al*., (2004) reported significant increase in grain and stover yields with increasing levels of sulphur in gram.

But interaction of irrigation scheduled at 0.7 IW/ CPE ratio with application of 20 kg S ha^{-1} (I_2S_2) recorded 32% higher grain yield over farmer's practice (I_4S_1) followed by I_2S_3 and I_3S_3 (Table.4).

Quality characters: Increasing frequency of irrigation significantly increased the protein content and protein yield and was recorded higher at 0.9 IW/CPE ratio. It was due to increased availability and uptake of nutrients under high moisture conditions which boosted the synthesis of amino acids and proteins (Dixit *et al*., 1993a and Reddy and Ahlawat, 1998).

Increased application of sulphur significantly increased the protein content and protein yield in gram and was recorded maximum when fertilized with 40 kg S ha^{-1}. This was due to the synthesis of more sulphur containing amino acids. Narendra Kumar *et al*., (2003) also reported increase in protein content with the application of sulphur in gram.

Moisture studies: Higher amount of moisture was extracted from surface layers irrespective of irrigation schedules. About 60-64% of moisture was extracted from 0-30 cm soil depth and around 90-95% moisture was extracted from 0-60 cm depth. With increasing frequency of irrigation from 0.5 to 0.9 IW/CPE ratio the per cent moisture extracted was also increased. It was further revealed that moisture extracted from deeper layers was higher in lower IW/CPE ratios. Dixit *et al*. (1993b) also reported the same trend in moisture extraction in gram (Table.3). The present study also revealed that scheduling irrigation from 0.5 to 0.9 IW/CPE ratio increased total consumptive use of water and decreased water use efficiency (Table.2). This was due to more consumption of water due to higher vegetative growth and comparatively

Table 3: Depth wise moisture extraction pattern (%) as influenced by irrigation and sulphur levels

Treatments	Soil depth (cm)				
	0-15	15-30	30-45	45-60	60-75
Irrigation: (IW/CPE ratios)					
I_1: 0.5	31.83	29.00 **(60.83)**	16.73 **(77.56)**	12.46 **(90.02)**	9.98 **(100.00)**
I_2: 0.7	32.63	29.55 **(62.18)**	18.74 **(80.92)**	13.47 **(94.39)**	5.61 **(100.00)**
I_3: 0.9	34.01	30.55 **(64.56)**	21.20 **(85.76)**	11.51 **(97.27)**	2.73 **(100.00)**
I_4: Farmer's practice	33.78	29.12 **(62.90)**	17.88 **(80.78)**	10.67 **(91.45)**	8.55 **(100.00)**
Sulphur levels (kg ha^{-1})					
S_1: 0	33.64	30.83 **(64.47)**	18.59 **(83.06)**	10.07 **(93.13)**	6.87 **(100.00)**
S_2: 20	31.97	29.27 **(61.24)**	18.86 **(80.10)**	13.13 **(93.23)**	6.77 **(100.00)**
S_3: 40	33.57	28.56 **(62.13)**	18.47 **(80.60)**	12.88 **(93.48)**	6.52 **(100.00)**

Note:- Data in parentheses indicates cumulative moisture extraction percentage up to that depth

Table 4: Interaction effect of irrigation and sulphur levels on number of nodules, yield, quality of grain and production economics of gram

Treatment	No. of nodules /plant	Yield (kg ha^{-1})		Protein content (%)	Protein yield (kg ha^{-1})	Gross realization (₹ ha^{-1})	Total expenditure (₹ ha^{-1})	Net realization (₹ ha^{-1})	BCR
		Seed	Stover						
I_1 S_1	18.9	1860	2338	17.7	328	42775	24804	17972	1.72
I_1 S_2	19.8	1636	2639	18.5	300	37861	25758	12103	1.47
I_1 S_3	23.9	1736	2531	20.2	351	40075	26711	13364	1.50
I_2 S_1	22.7	1914	3272	18.8	359	44364	25086	19278	1.77
I_2 S_2	23.4	2353	3657	22.2	523	54414	26041	28374	2.09
I_2 S_3	33.6	2330	3488	20.7	484	53826	26993	26832	1.99
I_3 S_1	27.0	2122	3457	21.6	457	49126	25369	23757	1.94
I_3 S_2	35.0	2276	3904	22.0	500	52777	26323	26454	2.00
I_3 S_3	31.5	2330	4012	22.8	531	54035	27276	26760	1.98
I_4 S_1	21.8	1782	2793	19.8	352	41221	24804	16418	1.66
I_4 S_2	22.5	1875	2963	21.0	395	43373	25758	17614	1.68
I_4 S_3	24.2	2099	2948	20.9	440	48401	26711	21690	1.81

lower grain yield per unit quantity of water at higher IW/CPE ratios. Same trend in CUW and WUE were observed by Arya *et al*., (2005).

It was revealed that application of 40 kg S ha^{-1} markedly increased the WUE in gram. Significant interaction between irrigation and sulphur was observed in number of nodules, pods and grain yield per plant, test weight, grain yield per ha, protein content and protein yield. Significant interaction between irrigation and sulphur was also reported by Patel and Patel (2005) in gram.

Economics: Irrigating gram at 0.9 IW/CPE ratio and fertilizing with 40 kg S ha^{-1} recorded maximum net returns and BCR individually (Table.2). But interaction of irrigation scheduled at 0.7 IW/CPE ratio with 20 kg S ha^{-1} recorded higher net returns and BCR (Table.4). Arya *et al*., (2005) and Pramanik *et al*., (2009) also recorded higher net returns and higher BCR at higher IW/CPE ratios.

CONCLUSION

From the present investigation it was revealed that irrigating gram (cv JG-16) at an IW/CPE ratio of 0.7 along with the application of 20 kg S ha^{-1} including recommended dose of fertilizers recorded higher yield, net realization and higher BCR under clayey soils of South Saurashtra agro-climatic zone.

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