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Response of Gram (*Cicer arietinum* L.) to Irrigation Schedules and Sulphur Levels

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ABSTRACT

A field experiment was carried out during *rabi* 2010 -11 to study the growth, yield, moisture extraction pattern, water use efficiency and quality of gram as influenced by irrigation schedules and sulphur levels. The study revealed that higher amount of moisture was extracted from surface layers irrespective of irrigation schedule and depletion of soil moisture increased with increasing frequency of irrigation. Grain yield and water use efficiency were influenced by different levels of irrigation. The highest water use efficiency (WUE) was recorded under farmer's practice and was lowest in irrigation scheduled at 0.9 IW/CPE ratio. The maximum values for all the growth parameters at various stages, yield attributes, grain and stover yield, moisture extraction and consumptive use of water along with net return and B : C ratio were obtained when irrigation was scheduled at an IW/CPE ratio of 0.9 and remained on par with 0.7 IW/CPE ratio. Application of sulphur significantly influenced the growth and yield attributes, yield and quality in gram. Application of 40 kg S ha^{-1} recorded higher grain yield, protein content, net return, and B : C ratio and was at par with 20 kg S ha^{-1}.

Key words : BCR, Gram, Irrigation schedules, Sulphur, WUE.

Gram commonly known as Chickpea or Bengalgram (*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 with an average productivity of 977 kg ha^{-1} (Singh, 2010). Since many years, farmers are following the same irrigation schedule without knowing it's feasibility under changed climatic conditions with limited water resourcesand changing cropping patterns thus for calls urgent need regarding application of water at an appropriate critical stage of the crop for ensuring better water use efficiency. Inspite of this, recent studies on soil fertility across the country showed that long term application of N, P and K fertilizers alone resulted in imbalance of nutrient ratios and led to sulphur deficiency in most of the states including the districts of Saurashtra region of Gujarat and further, sulphur was known to increase the yield and quality in gram (Narendra Kumar *et al*., 2003). Precise information regarding appropriate irrigation schedule and optimum sulphur dose for gram crop in recent years is very limited in Saurashtra region. Hence, the present investigation was carried out.

MATERIAL AND METHODS

The field experiment was conducted at the Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during 2010-11. The soil was clayey in texture, high in organic carbon (0.76%) low in available nitrogen (178.8 kg ha^{-1}) and K_2O (112.9 kg ha^{-1}) and sulphur (8.2 ppm), medium in available P_2O_5 (38.4 kg ha^{-1}) and alkaline in reaction with pH of 7.9.

The experiment was laid out in split-plot design comprising four levels of irrigation schedules 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)] were allotted to main plot and three levels of sulphur (S_1=0, S_2=20 and S_3=40 kg S ha^{-1}) allotted to sub plot and replicated thrice. The experimental site comprised of 36 plots each having 5.0m X 3.6m size. Sowing of gram (JG-16) was done using 60 kg seed ha^{-1} at a spacing of 45 cm x 10 cm and seed was treated with carbendazim at the time of sowing to prevent soil borne diseases. One intercultivation followed by a hand weeding was done at 40 DAS to control the weeds. Immediately after sowing light irrigation was

applied for proper germination and another common irrigation was given at 12 DAS for proper germination and ensuring better establishment of the crop. Afterwards each irrigation of 50 mm depth measured with parshall flume of 7.5 mm throat placed at the head irrigation channel was provided as per IW/CPE ratios and schedules under study. Besides initial two common irrigations, total of three (41, 60 and 82 DAS), four (33, 52, 68 and 80 DAS), five (29, 47, 57, 70 and 79 DAS) and three (29, 47 and 68 DAS) irrigations were given to I_1, I_2, I_3 and I_4 treatments, respectively. However no rainfall was received during the crop period and the treatments I_1, I_2, I_3 and I_4 received 250mm, 300mm, 350mm and 250mm, respectively. Sulphur was applied in soil as per treatments at 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. Observations on growth parameters, yield attributes, yield and quality parameters as well as moisture studies were recorded.

RESULTS AND DISCUSSION

Growth parameters

The growth and growth parameters were significantly influenced with frequency of irrigation. Giving five irrigations to gram (excluding 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, 90 DAS and at harvest. However, branches/plant, nodules and nodule dry weight/plant were the highest 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. Increase in number of irrigations at 0.9 IW/CPE ratio delayed the flowering and maturity due to prolonged vegetative growth whereas farmer's practice resulted in early maturity due to moisture deficit coupled with high temperatures. Application of 20 kg S ha^{-1} recorded significantly higher plant height at 90 DAS and harvest, plant spread and dry matter accumulation at 60 and 90 DAS which was at par with 40 kg S ha^{-1}. But plant height at 60 DAS, plant spread and drymatter 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 at later stages was due to it's higher availability and uptake at later stages as well as it's active involvement in synthesis of amino acids, regulation of various metabolic and enzymatic processes along with enhanced nitrogen fixation and biomass accumulation. Singh *et al*. (2004), Palsaniya and Ahlawat (2009) and Srinivasa Rao *et al*. (2010).

Yield attributes

Irrigating gram at 0.9 IW/CPE ratio recorded significantly maximum number of pods/ plant, seeds/pod, test weight, grain and stover yield followed by 0.7 IW/CPE ratio with significant disparity.The harvest index was not influenced by various irrigation levels. The irrigation schedule of 0.9 IW/CPE ratio exactly coincided with that of farmer's practice and further providing two more irrigations at peak vegetative stage and at the time of maturity thus, resulted 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 Arya *et al*. (2005). Application of sulphur @ 40 kg ha^{-1} resulted significantly higher number of pods per plant followed by 20 kg S ha^{-1}. Singh *et al*. (2004) reported the same results. Test weight, grain and stover yield per plant recorded maximum values with 20 kg S ha^{-1} followed by 40 kg S ha^{-1} (Table.2). Mishra *et al*. (2001) reported the similar results at Raipur.

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. And it remained on par with 0.7 IW/CPE ratio. Adequate moisture at root zone which favoured growth and yield attributes finally resulted in higher yields. These results are in complete agreement with those obtained by Umamaheshwari and Singh (2002). Patel and Patel (2000) observed the same trend in pigeon pea. Sulphur @ 40 kg ha^{-1} resulted in significantly higher grain yield (2,124 kg ha^{-1}) and was statistically at par with 20 kg S ha^{-1}. Whereas,

Table 1. Effect of irrigation schedules and sulphur levels on growth parameters of gram.

Treatment	Plant height (cm) at			Plant spread (cm)				Dry matter accumulation (g)/plant			Days to 50% flowering	Days to maturity	Nodules/ plant	Nodule dry weight/ plant (g)
	60 DAS	90 DAS	Harvest	60 DAS	90 DAS	Harvest	Branches/ plant	60 DAS	90 DAS	Harvest				
Irrigation schedules														
I_1: 0.5	29.6	36.4	33.5	26.5	34.0	18.8	6.4	3.7	14.7	14.8	52.8	86.4	20.8	0.20
I_2: 0.7	32.3	42.7	38.2	30.3	41.4	22.8	7.1	5.3	18.2	19.7	55.4	93.3	26.6	0.30
I_3: 0.9	34.0	45.8	42.2	32.1	43.5	23.4	7.9	5.7	20.8	20.9	57.4	95.9	31.1	0.34
I_4: Farmer's practice	31.5	35.0	34.7	29.8	34.6	18.5	7.4	4.2	16.0	16.3	50.9	85.8	22.9	0.21
S.Em.±	0.84	1.28	1.02	1.05	1.56	0.94	0.28	0.21	0.88	0.88	0.15	0.23	1.23	0.02
C.D. at 5%	2.91	4.42	3.53	3.62	5.40	3.24	0.97	0.73	3.05	3.06	0.51	0.81	4.25	0.05
Sulphur levels (kg ha^{-1})														
S_1: 0	30.9	38.9	35.7	28.6	37.5	19.63	6.6	4.2	15.6	16.7	54.2	90.3	22.6	0.24
S_2: 20	32.1	41.2	38.3	30.3	39.4	21.45	7.4	5.0	18.7	18.2	54.0	90.5	25.2	0.26
S_3: 40	32.5	39.9	37.5	30.1	38.2	21.52	7.7	5.0	18.1	18.8	54.3	90.3	28.3	0.29
S.Em.±	0.50	0.51	0.61	0.36	0.49	0.42	0.24	0.16	0.48	0.51	0.25	0.26	0.91	0.01
C.D. at 5%	NS	1.51	1.84	1.09	1.46	1.25	0.71	0.50	1.45	1.52	NS	NS	2.74	0.03
Interaction (I X S)														
S.Em.±	1.00	1.01	1.23	0.73	0.97	0.84	0.48	0.34	0.97	1.02	0.51	0.53	1.83	0.02
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	5.48	NS

maximum stover yield (3,291 kg ha^{-1}) was obtained with 20 kg S ha^{-1} which was on par with 40 kg S ha^{-1}. This potential increase of grain and stover yields with increasing level of sulphur was due to it's contribution on growth and yield attributes. Similar results were reported in gram by Srinivasa Rao *et al.* (2010) at IIPR, Kanpur.

Quality

Increased application of sulphur significantly increased the protein content and yield in gram and maximum was recorded when fertilized with 40 kg S ha^{-1}. This is due to the synthesis of more sulphur containing amino acids. Similar results were observed by Srinivasa Rao *et al.* (2010).

Moisture studies

With increasing depth of soil, per cent moisture extracted by the crop gradually decreased. It was also observed that 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 (Table.3). With increasing frequency of irrigation the per cent moisture extracted from the upper layers increased. However, at lower IW/CPE ratios the moisture extracted from deeper layers was increased. The present study further revealed that increasing IW/CPE ratio from 0.5 to 0.9 increased total consumptive use of water and decreased water use efficiency

Table 2. Effect of irrigation schedules and sulphur levels on yield attributes of gram.

Treatment	No. of pods/ plant	No. of seeds/ pod	Test weight (g)	Grain yield/ plant (g)	Stover yield/ plant (g)	Grain yield/ha (kg)	Stover yield/ ha (kg)	Harvest index (%)	Protein content (%)	Protein yield (kg/ha)	Gross realization (₹/ha)	Net realization (₹/ha)	BCR
Irrigation schedules													
I_1: 0.5	53.1	1.27	17.05	9.2	13.8	1744	2503	41.28	18.80	326	40241	14483	1.56
I_2: 0.7	58.4	1.25	17.74	11.8	17.5	2199	3472	38.69	20.57	455	50866	24826	1.95
I_3: 0.9	61.0	1.37	19.03	13.2	18.7	2243	3791	37.27	22.10	496	51984	25661	1.97
I_4: Farmer's practice	54.9	1.19	16.45	10.4	15.4	1919	2901	40.02	20.58	396	44338	18580	1.72
S.Em.±	1.34	0.03	0.28	0.47	0.86	103	209	1.24	0.28	21			
C.D. at 5%	4.63	0.10	0.95	1.64	2.97	357	725	NS	0.98	72			
Sulphur levels (kg ha^{-1})													
S_1: 0	52.5	1.26	16.62	9.4	15.6	1919	2965	39.65	19.46	374	44364	19349	1.77
S_2: 20	58.0	1.29	18.65	12.6	17.1	2035	3291	38.28	20.92	429	47104	21134	1.81
S_3: 40	60.1	1.25	17.44	11.4	16.4	2124	3245	40.00	21.16	451	49088	22165	1.82
S.Em.±	0.93	0.02	0.18	0.32	0.31	46	71	0.81	0.23	11			
C.D. at 5%	2.79	NS	0.53	0.95	0.94	137	212	NS	0.70	32			
Interaction (I X S)													
S.Em.±	1.86	0.04	0.35	0.63	0.62	92	142	1.62	0.47	22			
C.D. at 5%	5.57	NS	1.05	1.90	NS	274	NS	NS	1.40	65			

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

Treatment	Soil depth (cm)				
	0-15	15-30	30-45	45-60	60-75
Irrigation schedules					
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. Effect of irrigation schedules and sulphur levels on CUW and WUE in gram.

Treatment	Consumptive use of water (mm)	Water use efficiency (kg ha^{-1} mm^{-1})
Irrigation schedules		
I_1: 0.5	211	6.98
I_2: 0.7	248	7.33
I_3: 0.9	282	6.41
I_4: Farmer's practice	224	7.67
S.Em.±	6	0.41
C.D. at 5%	22	NS
Sulphur levels (kg ha^{-1})		
S_1: 0	238	6.75
S_2: 20	239	7.10
S_3: 40	246	7.44
S.Em.±	7	0.16
C.D. at 5%	NS	0.49
Interaction (I X S)		
S.Em.±	14	0.32
C.D. at 5%	NS	0.97

Table 5. Economics of gram production as influenced by irrigation schedules and sulphur levels in different treatment combinations.

Treatment	Yield (kg ha^{-1})		Gross realization (₹ ha^{-1})	Total expenditure (₹ ha^{-1})	Net realization (₹ ha^{-1})	Benefit: cost ratio
	Seed	Stover				
I_1 S_1	1860	2338	42775	24804	17972	1.72
I_1 S_2	1636	2639	37861	25758	12103	1.47
I_1 S_3	1736	2531	40075	26711	13364	1.50
I_2 S_1	1914	3272	44364	25086	19278	1.77
I_2 S_2	2353	3657	54414	26041	28374	2.09
I_2 S_3	2330	3488	53826	26993	26832	1.99
I_3 S_1	2122	3457	49126	25369	23757	1.94
I_3 S_2	2276	3904	52777	26323	26454	2.00
I_3 S_3	2330	4012	54035	27276	26760	1.98
I_4 S_1	1782	2793	41221	24804	16418	1.66
I_4 S_2	1875	2963	43373	25758	17614	1.68
I_4 S_3	2099	2948	48401	26711	21690	1.81

(Table.4). This was due to more consumption of water and higher vegetative growth at higher IW/ CPE ratios. It was also revealed that application of 40 kg S ha^{-1} markedly increased the WUE in gram.

Significant interaction between irrigation schedules and sulphur was observed in number of nodules, pods and grain yield per plant, test weight, grain yield ha^{-1}, protein content and protein yield.

Interaction between irrigation and sulphur was also reported by Mondal *et al*., (2003) in green gram and Patel and Patel (2005) in gram.

Economics

Irrigating gram at 0.9 IW/CPE ratio resulted in higher net returns (₹25,661/ha) as well as benefit cost ratio (1.97). Arya *et al*. (2005) also recorded higher net returns and BCR at higher IW/CPE ratios. Fertilizing gram with 40 kg S ha^{-1} recorded maximum net returns and BCR of 22,165/ha and 1.82, respectively (Table.5).

Conclusion

From the results it can be concluded that gram (cv JG-16) should be irrigated six times at an IW/CPE ratio of 0.7 and fertilized with 20 kg S ha^{-1} (8-10 days prior to sowing) along with recommended dose of 25.0 - 50.0 - 0.0 N-P-K kg ha^{-1} for getting higher yield and net realization under clayey soils of South Saurashtra agro-climatic zone.

LITERATURE CITED

Arya K L, Lalitkumar, Singh K K and Kushwaha B L 2005 Effect of fertilizers and tillage management in rice (*Oryza sativa*)- chickpea (*Cicer arietinum* L.) cropping system under varying irrigation schedules. *Indian Journal of Agronomy*, 50(4): 256-259.

Mishra S K, Shrivastava G K, Pandey D and Tripathi R S 2001 Optimization of chickpea production through nutrient management and growth regulators under rice based cropping system in vertisols. *Ann. agric. Res*., New series 22(2): 299-301.

Mondal S S, Ghosh A, Biswajitsarkar, Acharya D 2003 Studies on the effect of potassium, sulphur and irrigation on growth and yield of greengram. *Journal of Inter academicia* 7(3): 273-277.

Narendrakumar S S, Khangarot and Rajpal Meena 2003 Effect of sulphur and plant growth regulators on yield and quality parameters of chickpea (*Cicer arietinum* L.). *Ann. agric. Res*., New series 24(2): 434-436.

Palsaniya D R and Ahlawat I P S 2009 Sulphur management in pigeonpea (*Cajanus cujan*) – wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agron*omy, 54(3): 272-277.

Patel D B and Patel C L 2000 Effect of irrigation and planting geometry on growth and yield of winter pigeonpea. In: Extended Summaries, National Symposium on Agronomy: Challenges and Strategies for the New Millennium, November 15-18, 2000, GAU Campus, Junagadh, Gujarat. pp:145.

Patel R A and Patel R H 2005 Response of chickpea (*Cicer arietinum*) to irrigation, FYM and sulphur on a sandy clay loam soil. *International Chickpea and Pigeonpea Newsletter* (12): 22-24.

Singh N P 2010 Project Co-ordinators Report 2009-10, Annual group meet Aug. 29-31, 2010. AICRP on chickpea, IIPR, Kanpur, pp: 30-32.

Singh S, Saini S S and Singh B P 2004 Effect of irrigation, sulphur and seed inoculation on growth, yield and sulphur uptake of chickpea (*Cicer arietinum*) under late sown conditions. *Indian Jouranal of Agron*omy, 49(1): 57-59.

Srinivasarao Ch, Masoodali, Venkateswarlu S, Rupa T R, Singh K K, Sumantakundu and Prasad J V N S 2010 Direct and residual effects of integrated sulphur fertilization in maize (*Zea mays*) - chickpea (*Cicer arietinum*) cropping system on Typic Ustochrept. *Indian Journal of Agronomy*, 55(4): 259-263.

Umamaheswari P and Singh C P 2002 Influence of irrigation levels and micronutrients (Fe and Zn) on yield and yield attributes of rajmash (*Phaseolus vulgaris* L.). *Legume Research*, 25(2): 121-123.

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