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EFFECT OF IRRIGATION AND SULPHUR ON GROWTH, YIELD, NUTRIENT UPTAKE AND MOISTURE USE IN CHICKPEA (*Cicer arietinum* L.)

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ABSTRACT

A field experiment was carried out during *rabi,* 2010-11 to study the growth, yield, moisture extraction pattern and nutrient uptake in chickpea as influenced by irrigation and sulphur levels. Scheduling irrigation based on IW/CPE ratio and application of sulphur significantly influenced the growth, yield, moisture extraction pattern, nutrient uptake and quality of chickpea. Higher values for all these parameters along with net return and B : C ratio were obtained with scheduling irrigation at IW/CPE ratio of 0.9 which was statistically at par with 0.7 IW/CPE ratio. The study revealed that higher amount of moisture was extracted from surface layers irrespective of irrigation schedule and depletion of soil moisture by the crop increased with increasing frequency of irrigation. The highest water use efficiency was recorded under farmer's practice of irrigation schedule, while the lowest was recorded with IW/CPE ratio of 0.9. Among the three levels of sulphur *i.e.* 0, 20 and 40 kg ha^{-1}, application of 40 kg S ha^{-1} being at par with 20 kg S ha^{-1} recorded higher grain yield, net return and B : C ratio. But interaction of irrigation scheduled at 0.7 IW/CPE ratio with application of 20 kg S ha^{-1} recorded 32 % higher grain yield and higher B : C ratio over other treatment combinations.

KEYWORDS: B : C ratio, Chickpea, Chickpea, Irrigation, IW/CPE ratio, Sulphur.

INTRODUCTION

Bengalgram or chickpea (*Cicer arietinum* L.) is the most important pulse crop of India accounting 34.6 per cent area and 48.4 per cent production of total pulses with a productivity of 841 kg ha^{-1}. Considering the climatic change, limited water resources and replacement of new varieties with earlier ones along with changing cropping patterns calls urgent need for 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 (Singh, 1999) and further, sulphur was known to increase the yield and quality in chickpea (Narendra Kumar *et al*., 2003). Due to very limited information regarding appropriate irrigation interval and optimum sulphur dose for chickpea crop in recent years in South Saurashtra region, 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 *rabi*, 2010-11. The soil was clayey in texture, rich in organic carbon (0.76%), low in available nitrogen (178.75 kg ha^{-1}), potassium (112.90 kg ha^{-1}) and sulphur (8.15 ppm), medium in available phosphorus (38.40 kg ha^{-1}) and alkaline in reaction with pH of 7.9. The field capacity, permanent wilting point and bulk density of the soil were 28.4%, 12.8% and 1.36 Mg m^{-3}, respectively.

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 the 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 treatments and replicated thrice comprising 36 plots each having a size of 5.0 m X 3.6 m. Sowing of chickpea (var. JG-16) was done using 60 kg seed ha^{-1} at a spacing of 45 cm x 10 cm. Irrigation was scheduled as per the treatments each at 50 mm depth measured with parshall flume of 7.5 mm throat width placed at the head irrigation channel based on cumulative pan evaporation readings. Besides initial two common irrigations (1st immediately after sowing and 2nd at 10-12 DAS) a total of three (41, 60 and

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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. The quantity of water received by I_1, I_2, I_3 and I_4 treatments was 250 mm, 300 mm, 350 mm and 250 mm, respectively. Sulphur was applied to soil as per the 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. Depth wise moisture extraction and consumptive use of water by crop were studied by gravimetric method (Dastane, 1972). Observations on growth parameters, yield attributes, yield and quality were recorded.

RESULTS AND DISCUSSION

Effect of irrigation on growth and yield

Scheduling seven irrigations to chickpea (including two common irrigations) at IW/CPE ratio of 0.9 resulted in significantly higher plant height, plant spread, branches/plant, dry matter accumulation at harvest, number of nodules and nodule dry weight/plant, pods/plant, seeds/pod, test weight, grain and stover yield (Table.1). This was due to the availability of adequate moisture throughout crop growth and development contributing to luxurious uptake of nutrients, favourable physiological processes and active cell division. Increased frequency of irrigation from 0.5 to 0.9 IW/CPE ratio significantly delayed the flowering and maturity of the crop due to prolonged vegetative growth compared to farmer's practice. The extent of increase in grain and stover yields of chickpea 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 irrigation schedule of 0.9 IW/CPE ratio was exactly coincided with that of farmer's practice and further provided two more irrigations one at peak vegetative stage and another at the time of maturity thus, resulted in more number of well filled pods with large sized seeds. This finally resulted in higher grain and stover yield. The results obtained by Patel (1988), Parihar (1990) and Dixit *et al*. (1993a) were in corroborative with the above results. Increasing frequency of irrigation from 0.5 to 0.9 IW/CPE ratio significantly increased the nutrient uptake by the crop.

Effect of irrigation on nutrient uptake

Scheduling irrigation to chickpea at 0.9 IW/CPE ratio significantly increased the uptake of N, P, K and S by 20, 22, 18 and 27% and 41, 30, 37 and 43% by grain and stover respectively over the farmers practice (Table.2). Continuous availability of adequate moisture resulting in more available nutrients in soil solution, active root and shoot growth, increased biomass accumulation, luxurious growth of root nodules along with synergetic effect between moisture, soil microorganisms and nutrients may boosted nutrient availability and resulted in higher uptake by chickpea crop at 0.9 IW/CPE ratio. These results were in close agreement with findings of Reddy and Ahlawat (1998) and Singh *et al*. (2004).

Effect of irrigation on moisture use pattern

With increasing depth of soil, per cent moisture extracted by the crop gradually decreased. It was also revealed that about 60-64 per cent of moisture was extracted from top 0-30 cm soil depth and around 90-95 per cent 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.4). This was due to more consumption of water resulting in higher vegetative growth and decreasing trend of yield increase per unit water available from lower to higher IW/CPE ratios. Same trend in moisture extraction, CUW and WUE were observed by Prabhakar and Saraf (1991) and Dixit *et al*. (1993b).

Effect of sulphur on growth and yield

Application of 20 kg S ha^{-1} recorded significantly higher plant height and plant spread at harvest and was at par with 40 kg S ha^{-1}. Whereas, dry matter accumulation at harvest, number of nodules and nodule dry weight per plant were significantly higher when chickpea fertilized with 40 kg S ha^{-1} and at par with 20 kg S ha^{-1} (Table.1). Increase in growth parameters with increased levels of sulphur was 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 and biomass accumulation. Similar results were reported by Singh *et al*. (2004) and Srinivasa Rao *et al*. (2010). Application of sulphur @ 40 kg ha^{-1} resulted in significantly higher number of pods per plant followed by 20 kg S ha^{-1} (Table 1). Joseph and Verma (1994) and Singh *et al*. (2004) reported

Table 1. Growth and yield attributes of chickpea as influenced by different irrigation and sulphur levels

Treatments	Plant height at harvest (cm)	Plant spread at harvest (cm)	Dry matter per plant at harvest (g)	Days to 50% flowering	Days to maturity	No. of nodules per plant	Nodule dry weight (g)	No. of pods per plant	Grain yield per hectare (kg)	Stover yield per hectare (kg)	Test weight (g)	Harvest index (%)
Irrigation: (IW/CPE ratios)												
I_1: 0.5	33.5	18.8	14.8	52.8	86.4	20.8	0.197	53.1	1744	2503	17.05	41.28
I_2: 0.7	38.2	22.8	19.7	55.4	93.3	26.6	0.303	58.4	2199	3472	17.74	38.69
I_3: 0.9	42.2	23.4	20.9	57.4	95.9	31.1	0.342	61.0	2243	3791	19.03	37.27
I_4: Farmer's practice	34.7	18.5	16.3	50.9	85.8	22.9	0.214	54.9	1919	2901	16.45	40.02
S.Em.±	1.02	0.94	0.88	0.15	0.23	1.23	0.015	1.34	103.20	209.47	0.28	1.24
C.D. at 5%	3.53	3.24	3.06	0.51	0.81	4.25	0.053	4.63	357.15	724.88	0.95	NS
C.V.%	8.24	13.47	14.78	0.81	0.78	14.51	17.53	7.06	15.28	19.84	4.71	9.47
Sulphur levels (kg ha^{-1})												
S_1: 0	35.7	19.63	16.7	54.2	90.3	22.6	0.244	52.5	1919	2965	16.62	39.65
S_2: 20	38.3	21.45	18.2	54.0	90.5	25.2	0.263	58.0	2035	3291	18.65	38.28
S_3: 40	37.5	21.52	18.8	54.3	90.3	28.3	0.286	60.1	2124	3245	17.44	40.00
S.Em.±	0.61	0.42	0.51	0.25	0.26	0.91	0.009	1.0	46	71	0.2	0.81
C.D. at 5%	1.8	1.3	1.5	NS	NS	2.74	0.028	2.8	137	212	0.5	NS
C.V.%	5.7	7.0	9.8	1.6	1.0	12.5	12.3	5.7	8.0	7.8	3.5	7.1
Interaction (I X S)												
S.Em.±	1.23	0.84	1.02	0.51	0.53	1.83	0.019	1.86	91.51	141.74	0.35	1.62
C.D. at 5%	NS	NS	NS	NS	NS	5.48	NS	5.57	274.37	NS	1.05	NS
C.V.%	5.7	7.0	9.8	1.6	1.0	12.5	12.3	5.7	7.8	7.8	3.5	7.1

Table 2. N, P, K and S uptake (kg ha^{-1}) by chickpea grain and stover as influenced by different irrigation and sulphur levels

Treatments	Uptake (kg ha^{-1}) of											
	N			P			K			S		
	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total
Irrigation schedules												
I_1: 0.5	50.1	46.1	96.2	16.5	7.6	24.1	8.1	6.9	15.0	4.7	6.8	11.5
I_2: 0.7	*71.2*	65.8	137.0	20.0	10.7	30.6	10.3	10.2	20.5	6.4	10.6	17.0
I_3: 0.9	71.5	77.7	149.3	20.8	11.7	32.5	10.5	11.8	22.2	6.6	12.0	18.7
I_4: Farmer's practice	59.6	55.1	114.8	17.1	9.0	26.1	8.9	8.6	17.6	5.2	8.4	13.6
S.Em.±	4.0	4.8	8.3	1.2	0.6	1.6	0.5	0.7	1.2	0.3	0.6	0.8
C.D. at 5%	13.7	16.8	28.7	NS	1.9	5.6	1.7	2.3	4.0	1.2	1.9	2.9
C.V.%	18.9	23.7	20.0	19.2	17.2	17.3	15.8	21.5	18.3	17.9	17.8	16.3
Sulphur levels (kg ha^{-1})												
S_1**:** 0	58.8	56.9	115.7	17.0	8.9	25.9	8.9	8.6	17.5	5.3	8.4	13.6
S_2**:** 20	63.6	63.2	126.8	18.9	10.2	29.1	9.5	9.8	19.3	5.7	9.9	15.7
S_3**:** 40	67.0	63.5	130.5	19.8	10.2	30.0	10.0	9.7	19.7	6.2	10.1	16.3
S.Em.±	1.6	1.9	2.5	0.5	0.3	0.6	0.2	0.3	0.3	0.2	0.3	0.3
C.D. at 5%	4.9	5.6	7.4	1.6	0.8	1.7	0.7	0.8	0.9	0.5	0.8	0.8
C.V.%	9.0	10.5	6.9	9.8	9.5	6.9	8.8	9.7	5.3	9.8	9.8	6.3
Interaction (I X S)												
S.Em.±	3.3	3.7	4.9	1.1	0.5	1.1	0.5	0.5	0.6	0.3	0.5	0.6
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	9.0	10.5	6.9	16.5	7.6	24.1	8.8	9.7	5.3	9.8	9.8	6.3

Table 3. Depth wise moisture extraction pattern (%) by chickpea as influenced by different 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. Consumptive use of water, water use efficiency, net realisation and benefit cost ratio of chickpea as influenced by different irrigation and sulphur levels

Treatments	Consumptive use of water (mm)	Water use efficiency (kg ha^{-1} mm^{-1})	Gross realization (₹/ha)	Net realization (₹/ha)	B:C ratio
Irrigation: (IW/CPE ratios)					
I_1: 0.5	211	6.98	40241	14483	1.56
I_2: 0.7	248	7.33	50866	24826	1.95
I_3: 0.9	282	6.41	51984	25661	1.97
I_4: Farmer's practice	224	7.67	44338	18580	1.72
Sulphur levels (kg ha^{-1})					
S_1: 0	238	6.75	44364	19349	1.77
S_2: 20	239	7.10	47104	21134	1.81
S_3: 40	246	7.44	49088	22165	1.82

Table 5. Economics of chickpea production as influenced by different 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	17971	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	28373	2.09
I_2 S_3	2330	3488	53826	26993	26833	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	26759	1.98
I_4 S_1	1782	2793	41221	24804	16417	1.66
I_4 S_2	1875	2963	43373	25758	17615	1.68
I_4 S_3	2099	2948	48401	26711	21690	1.81

the same results. Maximum test weight recorded with the application of 20 kg S ha^{-1} followed by 40 kg S ha^{-1} (Table 1). Mishra *et al*. (2001) observed the same results at Raipur. Sulphur @ 40 kg ha^{-1} resulted in significantly higher grain yield and was statistically at par with 20 kg S ha^{-1}. Whereas, maximum stover yield was obtained with 20 kg S ha^{-1} being on same bar with 40 kg S ha^{-1} (Table 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. Hariram and Dwivedi (1992) and Joseph and Verma (1994) reported higher grain yields in chickpea with 40 kg S ha^{-1}. Significant increase in stover yields of chickpea with 20 kg S ha^{-1} was also reported by Srinivasa Rao *et al*. (2010).

Effect of sulphur on nutrient uptake

Increasing levels of sulphur from 0 to 40 kg ha^{-1} significantly increased nitrogen, phosphorus, potassium and sulphur uptake by the crop. Application of 40 kg S ha^{-1} resulted in 12.4, 15.8, 12.6 and 19.8 per cent higher uptake of N, P, K and S by the crop, respectively over control and was at par with 20 kg S ha^{-1} (Table 2). This increase in nutrient uptake with successive increase in sulphur up to 40 kg ha^{-1} could be attributed to increased availability of sulphur to plants which in turn might have resulted in more number of effective root nodules, profuse shoot and root growth contributing to higher biomass production, higher photosynthetic activity as well as synergistic effect of N-S and S-P may boosted their availability and absorption from the soil. These findings were in accordance with those of Kaprekar *et al.* (2003) and Singh *et al*. (2004).

Effect of sulphur on moisture use pattern

Significant trend in moisture extraction pattern was not observed with the application of sulphur. But it was showed that application of 40 kg S ha^{-1} markedly increased the WUE in chickpea (Table 3 and Table 4).

Interaction effect of irrigation and sulphur

Significant interaction between irrigation and sulphur was observed in number of nodules, pods and grain yield per plant, test weight and grain yield per ha (Table 1). Irrigating chickpea at 0.7 IW/CPE ratio along with the application of 20 kg S ha^{-1} resulted in maximum yield (Table.5). Interaction between irrigation and sulphur was also reported by Patel and Patel (2005) in chickpea.

Economics

Irrigating chickpea at 0.9 IW/CPE ratio resulted in higher net realisation as well as benefit cost ratio. Dixit *et al*. (1993a) also recorded higher net returns and B:C ratio at higher IW/CPE ratios. Fertilizing chickpea with 40 kg S ha^{-1} recorded maximum net returns and B:C ratio (Table 4). Results obtained by Singh *et al*. (2005) are also in conformity with the above results. But the present investigation revealed that combination of irrigating chickpea at 0.7 IW/CPE ratio along with the application of 20 kg S ha^{-1} resulted in maximum B : C ratio of 2.09 (Table 5).

CONCLUSION

The present investigation revealed that chickpea (cv JG-16) should be irrigated at IW/CPE ratio of 0.7 along with the application of 20 kg S ha^{-1} including recommended dose of fertilizers for higher grain yield in chickpea, net realization and higher B:C ratio under clayey soils of South Saurashtra agro-climatic zone.

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