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Research Article

MOISTURE EXTRACTION PATTERN AND ECONOMICS OF CHICKPEA (*CICER ARIETINUM* L.) AS INFLUENCED BY IRRIGATION SCHEDULES AND SULPHUR

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ABSTRACT
A comprehensive research programme was carried out on medium black clay soil of Junagadh Agricultural University, Junagadh, Gujarat during *rabi* 2010-11 to study the moisture extraction pattern, water use and to find out optimum sulphur requirement for chickpea under various irrigation schedules and sulphur levels. The study revealed that higher amount of moisture was extracted by the crop from surface layers irrespective of irrigation schedule and it increased with increasing IW/CPE ratio. 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 highest consumptive use of water (CUW) by the crop was recorded under irrigation schedule 0.9 IW/CPE ratio. Higher seed yield, along with net return and B: C ratio were obtained when irrigation was scheduled at an IW/CPE ratio of 0.9 and remained at par with 0.7 IW/CPE ratio. Application of 40 kg S ha^{-1} recorded higher CUW and significantly higher WUE. Application of 40 kg S ha^{-1} also recorded significantly higher seed yield, net return and B: C ratio and remained at par with 20 kg S ha^{-1}. However irrigating chickpea as per farmer's practice along with 40 kg S ha^{-1} recorded higher WUE and combination of 0.9 IW/CPE ratio with 40 kg S ha^{-1} recorded higher CUW. Similarly interaction between sulphur and irrigation levels, 20 kg S ha^{-1} and 0.7 IW/CPE has reported higher seed yield, net returns and B: C ratio.

Keywords: *Chickpea, IW/CPE Ratio, Sulphur, CUW, WUE and B: C ratio*

INTRODUCTION
Chickpea (*Cicer arietinum* L.) or Bengalgram is the most important pulse crop of India and Gujarat occupied 2.5% of chickpea area and 2.8% of production of the country (Singh, 2010). Irrigation scheduling is the process of determining when to irrigate and how much water to apply per irrigation. Proper irrigation scheduling is essential for the efficient use of water, energy and other production inputs. Since, long time farmers were growing chickpea under residual soil moisture or supplying irrigation to a limited extent leading to low productivity. But under today's climatic conditions there is immense scope for ensuring better water use efficiency and increasing productivity with the application of sufficient quantity of water at an appropriate critical stage of the crop. Soil fertility studies 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 South Saurashtra region of Gujarat and further, sulphur was known to increase the yield in chickpea (Narendra *et al*., 2003). Precise information regarding appropriate irrigation schedule and optimum sulphur dose for chickpea crop is very limited in Saurashtra region. Hence, the present investigation was carried out.

MATERIALS AND METHODS
The field experiment on "Effect of irrigation schedules and sulphur on moisture extraction pattern and economics on chickpea" in medium black clay soils of South Saurashtra region was conducted at the Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during 2010-11. The soil was medium black and clayey in texture, slightly alkaline (7.9) in reaction high in organic carbon (0.76%), low in available nitrogen (179 kg ha^{-1}), K_2O (113 kg ha^{-1}),

sulphur (8.2 ppm) and medium in available P_2O_5 (38 kg ha^{-1}). The field capacity, permanent wilting point and bulk density of the experimental plot 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 schedules based on IW/CPE ratios *viz*., 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) to 50mm depth 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 chickpea (var. JG-16) was done using 60 kg seed ha^{-1} at a spacing of 45cm x 10cm. Immediately after sowing and at 12 DAS light irrigations were given for proper germination and ensuring better establishment of the crop. Afterwards each irrigation of 50mm depth measured with parshall flume of 7.5mm throat width 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 growth period and the treatments I_1, I_2, I_3 and I_4 received in total 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. Depth wise moisture extraction and consumptive use of water by crop were studied by gravimetric method (Dastane, 1972). Observations on yield attributes and yield were recorded and evaluated economical viability of the system.

RESULTS AND DISCUSSION

Effect of Irrigation Schedules

Moisture Extraction Pattern in Chickpea as Influenced by Irrigation Schedules

Higher amount of moisture was extracted from surface layers and the per cent moisture extraction decreased with the increase in soil depths irrespective of various treatments. Percentage moisture extracted by the crop from top 0-30 cm and 0-60 cm depth in I_1, I_2, I_3 and I_4 treatments were 60.83, 62.18, 64.56 and 62.90 % and 90.02, 94.39, 97.27 and 91.45 %, respectively. About 60-64 % of moisture was extracted from 0-30 cm soil depth and around 27-32% moisture was extracted from next 30 cm depth (Table 1) i.e. more than half of the moisture used by chickpea from the top 30 cm soil layer and more than three-fourths from top 60 cm soil profile.

It revealed that the active root depth of chickpea was confined up to 60 cm depth. Increased frequency of irrigation not only resulted in more soil moisture extraction from the upper layers but also higher amount of moisture depletion from the entire root zone. This is because of additive effect of higher transpiration from the increased leaf area and more water loss from the soil surface through evaporation (Dixit *et al*., 1993; Pramanik *et al*., 2009). It was further revealed that moisture extracted from deeper layers was higher at low IW/CPE ratio which was indicating the penetration of roots to deeper layers in search of water.

The present study also showed that CUW by the crop decreased from surface to bottom layers irrespective of treatments but as frequency of irrigation increased from 0.5 to 0.9 IW/CPE ratio total CUW by the crop also increased. The increase in CUW by the crop from 0-30 cm in I_3 is 18.74 % and from 30-60 cm it was 49.20 %, 26.83 % in I_3 and I_2, respectively over farmer's practice. It was also noticed that the CUW by the crop from bottom 15 cm (i.e. 60-75 cm depth) is low especially in I_3 and I_4 (farmer's practice) compared to I_1 and I_2 (Table 2). The extent of increase in total CUW by the crop in I_3 and I_2 was to the tune of 25.89 and 10.71% over farmer's practice (I_4), respectively (Table 2). This increase in CUW in treatment with higher IW/CPE ratios was due to more availability of water for evapotranspiration (Dixit *et al*., 1993). Decrease in WUE at higher IW/CPE ratios was observed and farmer's practice of irrigation recorded higher WUE followed by I_2, I_1 and I_3 (Table 2). It was because of more consumption of water due to higher vegetative growth and comparatively lower seed yield per unit quantity of water utilised at higher IW/CPE ratios. Same trend in CUW and WUE were observed by Arya *et al.,* (2005).

Table 1: Depth wise moisture extraction pattern (in %) as influenced by irrigation and sulphur levels

Treatments	**Soil depth (cm)**				
	0-15	**15-30**	**30-45**	**45-60**	**60-75**
Irrigation schedules					
I_1: 0.5 IW/CPE ratio	31.83	29.00 (60.83)	16.73 (77.56)	12.46 (90.02)	9.98 (100.00)
I_2: 0.7 IW/CPE ratio	32.63	29.55 (62.18)	18.74 (80.92)	13.47 (94.39)	5.61 (100.00)
I_3: 0.9 IW/CPE ratio	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 2: Depth wise CUW (mm), total CUW, WUE, yield and economics as influenced by irrigation and sulphur

Treatments	**CUW(mm) Soil depth (cm)**					**Total CUW (mm)**	**WUE (kg ha^{-1} mm^{-1})**	**Seed yield (kg/ha)**	**Test weight (g)**
	0-15	**15-30**	**30-45**	**45-60**	**60-75**				
Irrigation schedules									
I_1: 0.5 IW/CPE ratio	69.51	62.63	35.32	24.40	18.87	211	6.98	1744	17.1
I_2: 0.7 IW/CPE ratio	82.20	68.53	47.37	35.86	14.09	248	7.33	2199	17.7
I_3: 0.9 IW/CPE ratio	96.90	80.76	60.06	37.85	6.79	282	6.41	2243	19.0
I_4: Farmer's practice	84.17	65.45	51.05	14.57	8.33	224	7.67	1919	16. 5
C.D. at 5%	-	-	-	-	-	21.66	NS	357	0.9
Sulphur levels (kg ha^{-1})									
S_1: 0	80.80	75.33	47.07	21.20	14.00	238	6.75	1919	16.6
S_2: 20	83.30	64.00	49.03	32.65	9.74	239	7.10	2035	18.7
S_3: 40	85.48	68.68	49.24	30.67	12.33	246	7.44	2124	17.4
C.D. at 5%	-	-	-	-	-	NS	0.49	137	0.5

Yield and Economics in Chickpea as Influenced by Irrigation Schedules

The present study on effect of irrigation schedules revealed significant influence on seed yield. The increase in seed yield of chickpea when irrigation scheduled at 0.9 and 0.7 IW/CPE ratios was by 16.88 % and 14.59 % over farmer's practice, respectively. The irrigation scheduled at 0.9 IW/CPE ratio was coincided with that of farmer's practice and further provided two more irrigations at peak vegetative stage and at the time of pod maturity thus, resulted in optimum moisture conditions throughout crop growth and development contributing to better availability and luxurious uptake of nutrients, favourable physiological processes, active cell division and photosynthesis. This ultimately resulted in more number of large sized seeds and higher seed yield. The results obtained by Chandrasekhar and Saraf (2005) are in corroborative with the above results. Irrigating chickpea at 0.9 IW/CPE ratio also resulted in higher net returns as well as benefit cost ratio (Table 2). Arya *et al*. (2005) also recorded higher net returns and BCR at higher IW/CPE ratios.

Table 3: Interaction effect of irrigation and sulphur on total consumptive use of water, water use efficiency, yield and economics

Treatment	Total CUW (mm)	WUE (kg ha^{-1} mm^{-1})	Seed yield (kg ha^{-1})	Test weight (g)	Gross realization (₹ ha^{-1})	Net realization (₹ ha^{-1})	B : C ratio
I_1 S_1	201	7.44	1860	16.5	42775	17971	1.72
I_1 S_2	218	6.54	1636	17.4	37861	12103	1.47
I_1 S_3	213	6.94	1736	17.3	40075	13364	1.50
I_2 S_1	247	6.38	1914	17.2	44364	19278	1.77
I_2 S_2	245	7.84	2353	18.7	54414	28373	2.09
I_2 S_3	252	7.77	2330	17.4	53826	26833	1.99
I_3 S_1	285	6.06	2122	17.4	49126	23757	1.94
I_3 S_2	266	6.50	2276	20.6	52777	26454	2.00
I_3 S_3	296	6.66	2330	19.1	54035	26759	1.98
I_4 S_1	221	7.13	1782	15.4	41221	16417	1.66
I_4 S_2	226	7.50	1875	17.9	43373	17615	1.68
I_4 S_3	224	8.40	2099	15.9	48401	21690	1.81
S.Em.±	13.52	0.32	91.51	0.35			
C.D. at 5%	NS	0.97	274	1.1			

Scheduling irrigation based on IW/CPE ratios also influenced the irrigation interval as mentioned in materials and methods. As long as crop was passing through different stages irrigation interval gradually decreased in I_2 and I_3 treatments which recorded higher yield. Whereas in farmer's practice and I_1 the irrigation interval was in increasing trend compared to previous stages. It was mainly due to increase in cumulative pan evaporation readings along with the crop growth.

Effect of Sulphur

Moisture Extraction Pattern in Chickpea as Influenced by Sulphur Levels

From the present investigation it was observed that up to 30 cm soil depth maximum moisture extraction (64.47 %) was reported in treatment S_1 (no sulphur) followed by S_3 (40 kg S ha^{-1}) and S_2 (20 kg S ha^{-1}) with 62.13 and 61.24 %, respectively. Similarly the moisture extracted by the crop from 0 to 60 cm depth was not markedly influenced and was in slightly increasing order from treatments S_1 to S_3 (Table 1).

Marked difference in total consumptive use of water was not observed under various levels of sulphur application. But application of sulphur markedly increased the WUE in chickpea and was to the tune of 10.22 % and 5.18 % with the application of 40 kg S ha^{-1} (S_3) and 20 kg S ha^{-1} (S_2), respectively over no sulphur (Table 2). This increase in WUE is due to increase in seed yield with same quantity of water supplied at different sulphur levels. The same results were also reported by Singh *et al*. (2004).

Yield and Economics in Chickpea as Influenced by Sulphur Levels

Application of sulphur significantly increased the seed yield in chickpea and was to the tune of 6.0% and 10.7% with the application of 20 and 40 kg S ha^{-1} respectively over control. This was due to increased availability and uptake of sulphur 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 which ultimately contributed on growth and yield. Singh *et al.*, (2004) and Srinivasa *et al.*, (2010) were also reported increased seed yield in chickpea with the application of 40 kg S ha^{-1}. Fertilizing chickpea with 40 kg S ha^{-1} recorded maximum net returns and benefit cost ratio (Table 2).

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Interaction Effect of Irrigation and Sulphur on Chickpea

Highest CUW was recorded when the crop was irrigated at 0.9 IW/CPE ratio along with the application of 40 kg S ha^{-1} (I_3S_3) followed by I_3S_1 and I_2S_3. Irrigating chickpea based on farmer's practice along with the application of 40 kg S ha^{-1} (I_4S_3) recorded higher WUE followed by 0.7 IW/CPE ratio with the application of 20 kg S ha^{-1} (I_2S_2). Significant interaction between irrigation and sulphur was observed in test weight and seed yield per ha. Interaction of irrigation at 0.7 IW/CPE ratio with the application of 20 kg S ha^{-1} (I_2S_2) recorded higher seed yield, net returns and B: C ratio over all other treatment combinations (Table 3). Malik *et al*., (2006) and Singh *et al*., (2005) also reported significant interaction between irrigation and sulphur in chickpea.

Conclusion

From the present study it was clearly shown that scheduling irrigation at 0.7 IW/CPE ratio along with the application of 20 kg S ha^{-1} to chickpea with recommended fertilizer dose recorded higher seed yield, higher net returns and B: C ratio with efficient water use in Southern Saurashtra agro-climatic zone of Gujarat.

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Respected Sir,

The article or its data has not been sent elsewhere for publication and is the part of M.Sc. thesis submitted by D.V. Srinivasulu under my guidance.

Therefore you are kindly requested to take further necessary action for the publication of our article and acknowledge.

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