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RESEARCH PAPER

Nutrient uptake, yield and protein content of chickpea (*Cicer arietinum* L.) as influenced by irrigation and sulphur levels in medium black soils

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Abstract : A field experiment was carried out at Junagadh Agricultural University, Junagadh, Gujarat during *Rabi* 2010-11 to study the nutrient uptake, yield and quality of chickpea as influenced by irrigation and sulphur levels. Irrigation and sulphur have shown significant influence on growth, yield, nutrient uptake and protein content of chickpea. Among four irrigation schedules, irrigation scheduled at 0.9 IW/CPE ratio recorded significantly higher values for nutrient uptake, grain and stover yield, protein content and BCR which was at par with 0.7 IW/CPE ratio. As for as sulphur levels are concerned application of 40 kg S ha^{-1} recorded significantly higher nutrient uptake, grain yield, protein content and BCR and was at par with application of 20 kg S ha^{-1}. However, interaction between sulphur and irrigation levels, 20 kg S ha^{-1} and 0.7 IW/CPE recorded higher seed yield and net returns.

Key Words : Chickpea, IW/CPE ratio, Sulphur, Nutrient uptake, Yield, BCR

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INTRODUCTION

Chickpea (*Cicer arietinum* L.) commonly known as bengal gram, is the most important pulse crop of India. Gujarat occupied 2.46 per cent of chickpea area and 2.80 per cent of production of the country (Singh, 2010). Studies on soil fertility across the country revealed 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 and quality in chickpea (Kumar *et al*., 2003). For the past several years farmers were following the same irrigation schedule without knowing it's feasibility under changed climatic conditions. Hence, under limited water resources 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 and uptake of nutrients. Precise information regarding appropriate irrigation schedule and optimum sulphur dose for chickpea crop in recent years is very limited in Saurashtra region. Hence, the present investigation was carried out.

MATERIAL AND METHODS

The field experiment on nutrient uptake, yield and protein content of chickpea (*Cicer arietinum* L.) as influenced by sulphur and irrigation levels in medium black soils of South

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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 (179kg ha^{-1}), K_2O (113kg ha^{-1}), sulphur (8.2 ppm) and medium in available P_2O_5 (38kg ha^{-1}). The field capacity, permanent wilting point and bulk density of the experimental plot were 28.4 per cent 12.8 per cent and 1.36 per cent Mg m^{-3}, respectively.

The experiment was laid out in Split Plot Design comprised of 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 5.0×3.6m size. Sowing of chickpea (var. JG-16) was done using 60 kg seed ha^{-1} at a spacing of 45×10 cm. One intercultivation followed by a hand weeding was done at 40 DAS to control the weeds. 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 50 mm 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. Observations on growth attributes, nutrient uptake, yield and protein content were recorded. The protein content in grain was determined by Lowry's method (Lowry *et al*., 1951). Soil parameters were analyzed in the laboratory by adopting standard procedures as authored by Jackson (1973).

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Effect of irrigation schedules :

Effect of irrigation schedules on growth and yield of chickpea:

Scheduling irrigation to chickpea at an IW/CPE ratio of 0.9 resulted significantly higher dry matter accumulation, number of root nodules, nodule dry weight, grain and stover yield, test weight, protein content and was at par with 0.7 IW/CPE ratio (Table 1).

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 per cent 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 grain and stover yield. The results obtained by Parihar (1990) and Dixit *et al*. (1993) are in corroborative with the above results.

Effect of irrigation schedules on nutrient uptake in chickpea:

Increasing frequency of irrigation from 0.5 to 0.9IW/CPE ratio significantly increased nutrient uptake by the crop. Scheduling irrigation to chickpea at 0.9 IW/CPE ratio showed significantly higher nitrogen, phosphorus, potassium and sulphur uptake by seed and stover and was at par with 0.7 IW/CPE ratio. The increase in uptake of N, P, K and S by seed was 20, 22, 18 and 27 per cent whereas by stover it was to the tune of 41, 30, 37 and 43 per cent, respectively over 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 micro-organisms and nutrients may boosted nutrient availability and resulted in higher uptake by chickpea crop at 0.9 IW/CPE ratio. These results are in close agreement with findings of Reddy and Ahlawat (1998); Singh *et al*. (2004) and Arya *et al*. (2005).

Effect of irrigation schedules on protein content in chickpea:

Scheduling irrigation at 0.9 IW/CPE ratio increased protein content by 7.4 per cent over farmer's practice (Table 1). This could be ascribed to greater nutrient uptake and their translocation forming the vote of enhanced photosynthetic and metabolic activities resulting in more protein synthesis and better partitioning of them to the ultimate sink. Besides this, higher N and S uptake by seed compiled with higher seed yield resulted in higher protein yield. These results corroborate the findings of Nimje (1991) and Reddy and Ahlawat (1998).

Effect of sulphur :

Effect of sulphur on growth and yield of chickpea :

Application of sulphur significantly influenced the growth and yield in chickpea. Higher dry matter accumulation,

Table 1 : Growth, yield and qualityof chickpea as influenced by irrigation and sulphur levels

Treatments	Dry matter at harvest (g)	No. of nodules/ plant	Nodule dry weight (g)	Seed yield/ ha (kg)	Stover yield/ ha (kg)	Test weight (g)	Harvest index (%)	Protein content (%)	Protein yield (kg/ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	BCR
Irrigation schedules												
I_1: 0.5	14.8	20.8	0.197	1744	2503	17.1	41.28	18.80	326	40241	14483	1.56
I_2: 0.7	19.7	26.6	0.303	2199	3472	17.7	38.69	20.57	455	50866	24826	1.95
I_3: 0.9	20.9	31.1	0.342	2243	3791	19.0	37.27	22.10	496	51984	25661	1.97
I_4: Farmer's practice	16.3	22.9	0.214	1919	2901	16. 5	40.02	20.58	396	44338	18580	1.72
S.E. ±	0.88	1.23	0.015	103.2	209.5	0.3	1.24	0.28	21.0			
C.D. (P=0.05)	3.1	4.3	0.05	357.2	724.9	0.9	NS	1.0	72.0			
C.V.%	14. 8	14.5	17.53	15.3	19.8	4.7	9.5	4.2	15.0			
Sulphur levels (kg ha^{-1})												
S_1: 0	16.7	22.6	0.244	1919	2965	16.6	39.65	19.46	374	44364	19349	1.77
S_2: 20	18.2	25.2	0.263	2035	3291	18.7	38.28	20.92	429	47104	21134	1.81
S_3: 40	18.8	28.3	0.286	2124	3245	17.4	40.00	21.16	451	49088	22165	1.82
S.E. ±	0.5	0.91	0.009	46.0	71.0	0.2	0.81	0.23	10.8			
C.D. (P=0.05)	1.5	2.7	0.03	137.0	212.0	0.5	NS	0.7	32			
C.V.%	9.8	12.5	12.3	8.0	7.8	3.5	7.1	3.9	9.0			
Interaction (I × S)												
S.E. ±	1.02	1.8	0.02	91.5	141.7	0.4	1.6	0.5	21.7			
C.D. (P=0.05)	NS	5.5	NS	274	NS	1.1	NS	1.4	65			
C.V.%	9.8	12.5	12.3	7.8	7.8	3.5	7.1	3.9	9.0			

NS= Non-significant

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

Treatments	Uptake (kg ha^{-1}) of											
	N			P			K			S		
	Seed	Stover	Total	Seed	Stover	Total	Seed	Stover	Total	Seed	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.E. ±	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. (P=0.05)	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.E. ±	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. (P=0.05)	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 × S)												
S.E. ±	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. (P=0.05)	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

NS= Non-significant

numbers of root nodules per plant, nodule dry weight, seed yield were obtained when chickpea was fertilized with 40 kg S ha^{-1} (Table 1).Whereas higher stover yield and test weight was recorded with 20 kg S ha^{-1}. Increase inseed yield with the application of 20 and 40 kg S ha^{-1} was to the tune of 6 per cent and 11 per cent, respectively over control. This was due to increased sulphur availability and uptake 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 Rao *et al*. (2010) were also reported higher seed yields in chickpea with the application of 40 kg S ha^{-1}.

Effect of sulphur on nutrient uptake in chickpea :

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 are in accordance with those of Kaprekar (2003), Singh *et al*. (2004) and Kumar *et al*. (2006).

Effect of sulphur on protein content of chickpea :

The increase in protein content was 7.5 and 8.0 per cent with the application of 20 and 40 kg S ha^{-1}, respectively over control (Table 1). Increase in protein content with the application of higher doses of sulphur might be due to increased root activity and translocation of higher nitrogen and sulphur resulting in the synthesis of more S containing amino acids such as methionine, cysteine and cystine. These results are in complete agreement with those obtained by Hariram and Dwivedi (1992), Tripathi *et al*. (1997) and Kumar *et al*. (2003).

Interaction effect of irrigation and sulphur on chickpea :

Significant interaction between irrigation and sulphur was observed in number of nodules per plant, number of pods per plant, grain yield per ha, test weight, protein content and protein yield (Table 3). Interactionof irrigation at 0.7 IW/CPE ratio with the application of 20 kg S ha^{-1}(I_2S_2) recorded higher grain yield, net returns and B : C ratio over all other treatment combinations. Malik *et al*. (2006) and Singh *et al*. (2005) also reported significant interaction between irrigation and sulphur in chickpea.

Conclusion :

The present study clearly shows that scheduling irrigation at 0.7 IW/CPE ratio along with 20 kg S ha^{-1} with recommended fertilizer dose recorded higher chickpea yield, higher net returns and B : C ratio in Southern Saurashtra agro-climatic

Table 3 : Interaction effect of irrigation and sulphur levels on growth, yield, protein content and protein yield

Treatments	No. of nodules/plant	Seed yield (kg ha^{-1})	Test weight (g)	Protein content (%)	Protein yield (kg ha^{-1})	Gross realization (Rs. ha^{-1})	Total expenditure (Rs. ha^{-1})	Net realization (Rs. ha^{-1})	B : C ratio
$I_1 S_1$	18.9	1860	16.5	17.7	328	42775	24804	17971	1.72
$I_1 S_2$	19.8	1636	17.4	18.5	300	37861	25758	12103	1.47
$I_1 S_3$	23.9	1736	17.3	20.2	351	40075	26711	13364	1.50
$I_2 S_1$	22.7	1914	17.2	18.8	359	44364	25086	19278	1.77
$I_2 S_2$	23.4	2353	18.7	22.2	523	54414	26041	28373	2.09
$I_2 S_3$	33.6	2330	17.4	20.7	484	53826	26993	26833	1.99
$I_3 S_1$	27.0	2122	17.4	21.6	457	49126	25369	23757	1.94
$I_3 S_2$	35.0	2276	20.6	22.0	500	52777	26323	26454	2.00
$I_3 S_3$	31.5	2330	19.1	22.8	531	54035	27276	26759	1.98
$I_4 S_1$	21.8	1782	15.4	19.8	352	41221	24804	16417	1.66
$I_4 S_2$	22.5	1875	17.9	21.0	395	43373	25758	17615	1.68
$I_4 S_3$	24.2	2099	15.9	20.9	440	48401	26711	21690	1.81
S.E. ±	1.8	91.5	0.4	0.5	21.7				
C.D. (P=0.05)	5.5	274	1.1	1.4	65				
C.V.%	12.5	7.8	3.5	3.9	9.0				

zone of Gujarat.

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