

Effect of Irrigation and Iron Levels on Yield of Sunflower in Vertisols of Malaprabha Command in Northern Karnataka, India

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Abstract A field experiment was conducted during 2014-15 on vertisols of Malaprabha Command. The experiment involved two levels schedule of irrigations and nine fertilizer levels. Pooled data of the years 2014-15 and 2015-16 indicated that irrigation level (0.8 IW/CPE ration) did not show significant difference in sunflower grain yield (17.67 q/ha) as compared to irrigation at critical stages of the crop (17.30 q/ha). Fertilizer levels significantly increased the plant height, ear head diameter, grain yield and stalk yield of sunflower. The sunflower grain Yield (19.26 q/ha) was significantly superior at RPP + 25 kg FeSO₄/ha+ 0.75% FeSO₄ spray (30 DAS) + 1.5% lime as compare to rest of the treatments. The gross income, net income and B : C ratio were also sig-

nificantly superior at RPP + 25 kg FeSO₄/ha + 0.75 % FeSO₄ spray (30 DAS) + 1.5 % lime.

Keywords IW-Irrigation water, CPE-Cumulative pan evaporation, WUE-Water use efficiency, ZnSO₄, FeSO₄.

Introduction

Karnataka is one of the major producers of sunflower in the country. Karnataka with a production of 3.04 lakh tonne from an area of 7.94 lakh hectare followed by Andhra Pradesh, Maharashtra, Bihar, Orissa and Tamil Nadu are major sunflower producing states of India. sunflower crop is highly sensitive to water stress between flowering and grain filling stages. Therefore, irrigation may be provided in case of moisture deficiency during critical stages. Irrigation requirement of crop during summer is relatively higher. Among the various stages, bud initiation, flowering period and seed development stages are critical stages in terms of irrigation. Continuous use of only NPK fertilizer without application of organics and micronutrient fertilizer has been reported deficiency of Fe and Zn in Vertisols of Malaprabha Command [1], which might result decline in the productivity of irrigated sunflower in Vertisols of Malaprabha Command. No information

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Table 1. Plant height (cm), head diameter (cm), grain yield (q/ha) and water use efficiency (kg/ha mm) of sunflower as influenced by irrigation and iron levels and their interaction (pooled data of 2014-15 and 2015-16).

Treatments	Plant height (cm) pooled			Head diameter (cm) pooled			Grain yield (q/ha pooled)			Water use efficiency (kg/ha mm) pooled		
	I ₁ = 0.8 IW	I ₂ = Critical		I ₁ = 0.8IW/	I ₂ = Critical		I ₁ = 0.8IW/	I ₂ = Critical		I ₁ = 0.8IW/	I ₂ = Critical	
	CPE	stage	Mean	CPE	Stage	Mean	CPE	stage	Mean	CPE	Stage	Mean
F ₁ =RPP (recommended NPK (90 : 90 : 60) + 100 kg gypsum + 10 kg ZnSO ₄ + 8t FYM/ha + 0.5% borax spray at ray floret stage)	187.8	184.2	186.0	17.25	19.02	16.63	16.13	15.80	15.97	4.93	6.08	5.50
F ₂ =RPP + 10 kg FeSO ₄ /ha	192.6	189.5	191.0	18.42	17.02	17.72	16.70	16.57	16.63	5.10	5.89	5.50
F ₃ =RPP + 25 kg FeSO ₄ /ha	194.5	192.2	193.4	18.85	17.68	18.27	17.57	17.03	17.3	5.37	6.05	5.71
F ₄ = RPP + 0.5% FeSO ₄ spray (30 DAS) + 1% lime	194.8	193.5	194.1	18.68	17.67	18.17	16.75	16.63	16.69	5.11	6.01	5.56
F ₅ = RPP + 0.75% FeSO ₄ spray (30 DAS) + 1.5% lime	201.4	199.2	200.3	18.68	17.93	18.31	16.90	16.63	17.77	5.16	5.98	5.57
F ₆ = RPP + 10 kg FeSO ₄ /ha + 0.5% FeSO ₄ spray (30 DAS) + 1% lime	201.4	197.6	199.5	19.53	18.62	19.08	18.05	17.92	17.98	5.51	6.38	5.95
F ₇ = RPP + 25 kg FeSO ₄ /ha + 0.5% FeSO ₄ spray (30 DAS) + 1% lime	202.1	198.5	200.3	19.87	18.97	19.42	19.25	17.98	18.62	5.88	6.8	6.34
F ₈ = RPP + 10kg FeSO ₄ /ha+ 0.75% FeSO ₄ spray (30 DAS) + 1.5% lime		201.1	198.5	199.8	19.87	19.1	19.48	18.25	18.05	18.15	5.57	6.62
6.10												
F ₉ = RPP 25 kg FeSO ₄ /ha + 0.75% FeSO ₄ spray (30 DAS) + 1.5% lime	200.9	200.8	200.8	19.27	18.85	19.06	19.40	19.12	19.26	5.92	6.77	6.35
Mean	197.4	194.9	196.1	18.93	17.98	18.46	17.67	17.30	17.49	5.40	6.29	5.84
	SEm ±		CD (0.05)	SEm ±		CD (0.05)	SEm ±		CD (0.05)	SE m ±		CD (0.05)
Irrigation	0.745		NS	0.088		0.534	0.212		NS	0.030		0.180
Nutrient	0.971		2.798	0.249		0.716	0.195		0.563	0.061		0.176
I × N	1.494		NS	0.343		NS	0.336		NS	0.087		NS

available on response of sunflower to iron deficiency in the Malaprabha Command. In order to correct iron (Fe) deficiency and increase the productivity of sunflower this experiment was initiated.

Materials and Methods

A field experiment was conducted during *kharif* season for two years (2014-15 and 2015 -16) on a Vertisol of Malaprabha Command at Irrigation Water Management Center, Belvatagi. The soil sample of the experimental site was clayey in texture with pH 8.40; EC-0.20 dS/m, organic carbon -0.55%, available N, P₂O₅ and K₂O, 230, 31 and 765 kg/ha respectively. Available Zn (0.52 ppm) and Fe (2.9 ppm) are lesser than the critical limits in soils. The experiment involved two levels of irrigations : I₁ =

0.8 IW/CPE and I₂ = Irrigation at critical stages (germination, flowering and seed filling stage) and nine fertilizer levels (F₁ = RPP, F₂ = RPP + 10 kg FeSO₄/ha, F₃ = RPP + 25 kg FeSO₄/ha, F₄ = RPP + 0.5% FeSO₄ spray (30 DAS) + 1% lime, F₅ = RPP + 0.75% FeSO₄ spray (30 DAS) + 1.5% lime, F₆ = RPP + 10 kg FeSO₄/ha + 0.5% FeSO₄ Spray (30 DAS) + 1% lime, F₇ = RPP + 25 kg FeSO₄/ha 0.5% FeSO₄ spray

Table 2. Average water saving in percentage for the *kharif* sunflower crop for the years 2014-15 and 2015-16.

Treatments	Depth of irrigation water (mm)			Saving of water (Percentage)
	2014-15	2015-16	Mean	
I ₁ = 0.8 IW / CPE	355.1	302.8	329	...
I ₂ = Critical stages of crop	295.1	242.8	269	18.23

Table 3. Uptake of Fe (g/ha), Zn (g/ha), Sulfur (kg/ha) and oil content (%) of sunflower as influenced by irrigation and iron levels and their interaction (pooled data of 2014-15 and 2015-16).

Treatments	Fe (g/ha)			Zn (g/ha)			Sulfur (kg/ha)			Oil Content (%)		
	I ₁ =	I ₂ =	Mean	I ₁ =	I ₂ =	Mean	I ₁ =	I ₂ =	Mean	I ₁ =	I ₂ =	Mean
	0.8 IW/ CPE	Critical stage		0.8 IW/ CPE	Critical stage		0.8 IW/ CPE	Critical stage		0.8 IW/ CPE	Critical stage	
F ₁ = RPP (Recommended NPK (90 : 90 : 60) + 100 kg gypsum + 10 kg ZnSO ₄ + 8t FYM/ha + 0.5% borax spray at ray floret stage)	920.3	906.7	913.5	162.8	161.2	162.0	11.9	11.7	11.8	37.42	38.15	37.28
F ₂ = RPP + 10 kg FeSO ₄ /ha	991.7	977.8	984.7	171.9	173.6	172.7	13.2	12.9	13.0	37.67	37.48	37.57
F ₃ = RPP + 25kg FeSO ₄ /ha	1064.7	1063.4	1064.11	180.6	181.4	181.0	14.0	13.9	14.0	37.99	37.87	37.93
F ₄ = RPP + 0.5% FeSO ₄ spray (30 DAS) + 1% lime	1012.8	977.5	995.1	171.9	169.3	170.6	13.2	12.9	13.1	37.70	37.58	37.64
F ₅ = RPP + 0.75% FeSO ₄ spray (30 DAS) + 1.5% lime	1027.0	987.4	1007.2	175.4	169.6	172.5	13.5	13.2	13.3	37.99	37.87	37.93
F ₆ = RPP + 10 kg FeSO ₄ /ha + 0.5% FeSO ₄ spray (30 DAS) + 1% lime	1095.9	1065.3	1080.6	185.1	181.6	183.3	14.3	14.3	14.3	37.90	37.96	37.93
F ₇ = RPP + 25kg FeSO ₄ /ha + 0.5% FeSO ₄ spray (30 DAS) + 1% lime	1186.5	1183.9	1185.2	196.0	197.4	196.7	15.4	15.5	15.5	38.32	38.10	38.21
F ₈ = RPP + 10 kg FeSO ₄ /ha + 0.75% FeSO ₄ spray (30 DAS) + 1.5% lime	1153.9	1132.8	1143.4	190.1	189.6	189.8	15.1	15.1	15.1	38.30	38.14	38.22
F ₉ = RPP + 25 kg FeSO ₄ /ha + 0.75% FeSO ₄ spray (30 DAS) + 1.5% lime	1227.7	1196.1	1211.9	202.2	200.8	201.5	16.1	15.9	16.0	38.48	38.37	38.43
Mean	1075.6	1054.5	1065.1	181.8	180.5	181.1	14.1	13.9	14.0	37.97	37.84	37.90
	SEm ±	CD (0.05)		SEm ±	CD (0.05)		SEm ±	CD (0.05)		SEm ±	CD (0.05)	
Irrigation	5.748	NS		2.150	NS		0.102	NS		0.055	NS	
Nutrient	9.980	28.753		1.797	5.176		0.156	0.448		0.040	0.116	
I × N	14.495	NS		3.219	NS		0.231	NS		0.077	NS	

(30 DAS) + 1% lime, F₈ = RPP 10 kg FeSO₄/ha + 0.75% FeSO₄ spray (30 DAS) + 1.5% lime, F₉ = RPP + 25 kg FeSO₄/ha + 0.75% FeSO₄ spray (30 DAS) + 1.5% lime. Soil and plant analysis were carried out by using standard procedures [2].

Results and Discussion

Pooled data of the years 2014-15 and 2015-16 indicated that fertilizer levels significantly increased plant height (200.8 cm), head diameter (19.06 cm), grain yield (19.26 q/ha), stalk yield (47.89 q/ha) and water use efficiency (6.35 kg/ha mm) with the application of fertilizer RPP + 25 kg FeSO₄/ha + 0.75% FeSO₄ spray (30 DAS) + 1.5% lime as compared to rest of the treatments (Tables 1 and 2). This might be due to higher uptake of sulfur (16.0 kg/ha), zinc (201.5 g/ha) and iron (1211.9 g/ha) by sunflower

(Table 3) with application of fertilizer RPP + 25 kg FeSO₄/ha + 0.75 % FeSO₄ spray (30 DAS) + 1.5% lime as compared to only RPP (uptake of sulfur 11.8 kg/ha, zinc 162 g/ha and iron 913.5 g/ha). Similarly sunflower oil content (%) significantly increased with application fertilizer RPP + 25 kg FeSO₄/ha + 0.75% FeSO₄ spray (30 DAS) + 1.5% lime (38.43%) as compared to RPP only (37.28%). Similar results were recorded with foliar application of iron to sunflower. Two years pooled data did not recorded significant difference in the sunflower grain yield with irrigation levels i.e. 0.8 IW/CPE ratio (17.67 q/ha) and irrigation at critical stage of the crop (17.30 q/ha). Average water saving (two years 2013-14 and 2014-15) was 18.23% with irrigation at critical stages of crop (Table 2) as compared to irrigation at 0.8 IW/CPE. These results are in conformity with the findings of kaushal et al. [3]. Pooled data of two years indicated that significantly more gross return (Rs 47,151/ha), net return (Rs 31,264/

Table 4. Economics of sunflower as influenced by irrigation and iron levels and their interaction (pooled of the years 2014-15 and 2015-16).

Treatments	Gross income (Rs)			Net income (Rs)			B : C ratio		
	I ₁ =	I ₂ =	Mean	I ₁ =	I ₂ =	Mean	I ₁ =	I ₂ =	Mean
	0.8 IW/ CPE	Critical stage		0.8 IW/ CPE	Critical stage		0.8 IW/ CPE	Critical stage	
F ₁ = RPP (Recommended NPK (90 : 90 : 60) + 100 kg gypsum + 10 kg ZnSO ₄ + 8t FYM/ha + 0.5% borax spray at ray floret stage)	39497	38683	39090	26045	26271	26158	2.99	3.17	3.08
F ₂ = RPP + 10 kg FeSO ₄ /ha	40887	40558	40723	26735	27606	27171	2.94	3.14	3.04
F ₃ = RPP + 25 kg FeSO ₄ /ha	38017	41703	39860	27855	27341	27598	2.88	2.99	2.93
F ₄ = RPP + 0.5% FeSO ₄ spray (30 DAS) + 1% lime	41007	40723	40865	26430	27266	26848	2.86	3.06	2.96
F ₅ = RPP + 0.75% FeSO ₄ spray (30 DAS) + 1.5% lime	41378	40723	41051	26466	25811	26139	2.81	2.79	2.80
F ₆ = RPP + 10 kg FeSO ₄ /ha 0.5% FeSO ₄ spray (30 DAS) + 1% lime	44197	43870	44033	28960	29938	29449	2.94	3.17	3.06
F ₇ = RPP + 25 kg FeSO ₄ /ha + 0.5% FeSO ₄ spray (30 DAS) + 1% lime	47130	46477	46803	31363	31710	31536	2.93	3.08	3.01
F ₈ = RPP + 10 kg FeSO ₄ /ha + 0.75% FeSO ₄ spray (30 DAS) + 1.5% lime	44685	44193	44439	29633	29701	29667	2.90	3.07	2.99
F ₉ = RPP + 25 kg FeSO ₄ /ha 0.75% FeSO ₄ spray (30 DAS) + 1.5% lime	47498	46803	47151	31236	31291	31264	2.89	3.03	2.96
Mean	42699	42637	42668	28302	28549	28426	2.90	3.06	2.98
	SEm ±		CD (0.05)	SE m ±		CD (0.05)	SEm ±		CD (0.05)
Irrigation	562.4		NS	308.6		NS	0.021		0.128
Nutrient	896.2		2582.0	249.6		719.2	0.024		0.069
I × N	1320.7		NS	453.9		NS	0.038		0.110

ha) and B : C ratio (2.96) found with application of RPP + 25 kg FeSO₄/ha + 0.75% FeSO₄ spray (30 DAS) + 1.5% lime as compared to rest of treatments (Table 4).

Conclusion

From the present study it could be concluded that the application of fertilizer recommended package of practices, (recommended NPK (90 : 90 : 60) + 100 kg gypsum + 10 kg ZnSO₄ + 8t FYM/ha + 0.5% borax spray at ray floret stage + 25 kg FeSO₄/ha + 0.75% FeSO₄ spray (30 DAS) + 1.5% lime increased plant height, head diameter, grain yield, stalk yield, water use efficiency gross return, net return and B :

C ratio of sunflower over other treatments under irrigated condition.

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