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Water, Zinc and Iron Requirement of Wheat under Vertisols of Malaprabha Command in Northern Karnataka, India

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Abstract An experiment was conducted under irrigated condition in Vertisol to study the optimum water, zinc and iron requirement for wheat under Vertisols. Pooled data of the years 2013-14, 2014-15 and 2015-16 indicated that irrigation @ 0.8 IW/CPE ratio significantly increased grain yield (19.52 q/ha) and straw yield (55.14 q/ha) as compared to 0.6 IW/CPE ratio: grain yield (18.86 q/ha) and straw yield (53.23 q/ha). Among the fertilizer levels, significantly more grain yield (23.22 q/ha), straw yield (60.16 q/ha) and water use efficiency (6.30 kg/ha.mm) with the RDF + FYM + 20 kg $ZnSO_4$+20 kg $FeSO_4$ /ha application as compared to rest of treatments. Similarly, significantly more gross return, net return and B:C ratio was found with irrigating the crop @ 0.8 IW/CPE ratio as compared to @ 0.6 IW/CPE ratio. Among fertilizer levels, significantly more gross return, net return and B:C ratio were found with application of RDF + FYM +20 kg $ZnSO_4$ + 20 kg $FeSO_4$ /ha as compared to rest of treatments.

Keywords IW-Irrigation water, CPE-Cumulative pan evaporation,UE-Water use efficiency, $ZnSO_4$, $FeSO_4$.

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Introduction

Continuous use of only NPK fertilizer without application of organics and micronutrient fertilizer has been reported deficiency od Fe and Zn in Vertisols of Malaprabha Command [1], which might result decline in the productivity of irrigated wheat in Vertisols Malaprabha Command. Significant increase in the wheat yield and its quality by managing the Fe, Zn and Mn deficiencies [2]. No information available on response of wheat to micronutrient in the Malaprabha Command. In order to correct Fe and Zn deficiency and increase the productivity of wheat this experiment is proposed.

Materials and Methods

A field experiment was conducted for three years during *rabi* season (2013-14, 2014-15 and 2015-16) on a Vertisol of 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–0.53%, available N, P_2O_5 and K_2O 210, 30 and 780 kg/ha respectively. Available Zn (0.52 ppm) and Fe (3.8 ppm) are lesser than the critical limits in soils. The experiment involved two levels of moisture regime (I_1 = 0.8 IW/CPE and I_2 = 0.6 IW/CPE) and ten fertilizer levels (F_1 = RDF + FYM, F_2 = F_1 + 15 kg S/ha (through gypsum), F_3 = F_1 +10 kg $ZnSO_4$, F_4 =F_1+ 20 kg $ZnSO_4$, F_5 = F_1+ 10 kg $FeSO_4$, F_6 = F_1 + 20 kg $FeSO_4$, F_7 = F_1 + 10 kg $ZnSO_4$ + 10 kg $FeSO_4$/ha, F_8 = F_1 + 10 kg $ZnSO_4$+20 kg $FeSO_4$, F_9 = F_1+20 kg $ZnSO_4$ +10 kg

Table 1. Effect of irrigation and nutrient levels on plant height (cm), grain yield (q/ha), straw yield, water use efficiency (kg/ha.mm) of wheat (pooled data of the years 2013-14, 2014-15 and 2015-16).

	Plant height (cm)			Grain yield (q/ha)		
Treatments	I_1 =0.8 IW/ CPE	I_2 =0.6 IW/ CPE	Mean	I_1 =0.8 IW/ CPE	I_2 =0.6 IW/ CPE	Mean
F_1 = RDF + FYM	76.50	76.69	76.60	16.34	15.54	15.94
F_2 = F_1+15 kg S/ha (Through gypsum)	79.03	78.89	78.96	17.70	16.46	17.08
F_3 = F_1 + 10 kg $ZnSO_4$	80.10	79.84	79.97	18.38	18.08	18.23
F_4 = F_1 + 20 kg $ZnSO_4$	81.06	80.79	80.92	19.17	18.58	18.88
F_5 = F_1 + 10 kg $FeSO_4$	80.20	80.10	80.15	18.31	18.08	18.19
F_6 = F_1 + 20 kg $FeSO_4$	80.71	81.12	80.92	19.12	18.69	18.90
F_7 = F_1 + 10 kg $ZnSO_4$+10 kg $FeSO_4$/ha	82.18	82.06	82.12	19.98	19.34	19.66
F_8 = F_1 + 10 kg $ZnSO_4$+20 kg $FeSO_4$	82.68	82.47	82.57	20.82	20.11	20.46
F_9 = F_1 + 20 kg $ZnSO_4$+10 kg $FeSO_4$	82.97	82.91	82.94	21.59	21.11	21.35
F_{10} = F_1 + 20 kg $ZnSO_4$+20 kg $FeSO_4$	83.48	83.73	83.61	23.81	22.63	23.22
Mean	80.89	80.86	80.88	19.52	18.86	19.19
	SEm±	CD (0.05)		SEm±	CD (0.05)	
Irrigation	0.345	NS		0.050	0.305	
Nutrients	0.326	0.934		0.316	0.907	
I × N	0.557	NS		0.427	NS	

Table 1. Continued.

	Straw yield (q/ha)			Water use efficiency (kg/ha.mm)		
Treatments	I_1 =0.8 IW/ CPE	I_2 =0.6 IW/ CPE	Mean	I_1 =0.8 IW/ CPE	I_2 =0.6 IW/ CPE	Mean
F_1 = RDF + FYM	48.07	45.99	47.03	4.10	4.55	4.33
F_2 = F_1+15 kg S/ha (Through gypsum)	51.38	47.95	49.66	4.38	4.83	4.60
F_3 = F_1 + 10 kg $ZnSO_4$	53.64	51.92	52.78	4.52	5.24	4.88
F_4 = F_1 + 20 kg $ZnSO_4$	56.22	53.47	54.85	4.73	5.36	5.05
F_5 = F_1 + 10 kg $FeSO_4$	50.61	49.43	50.02	4.49	5.25	4.87
F_6 = F_1 + 20 kg $FeSO_4$	54.46	51.99	53.23	4.71	5.36	5.03
F_7 = F_1 + 10 kg $ZnSO_4$+10 kg $FeSO_4$/ha	58.22	55.99	57.11	4.99	5.61	5.30
F_8 = F_1 + 10 kg $ZnSO_4$+20 kg $FeSO_4$	58.81	57.77	58.29	5.18	5.81	5.50
F_9 = F_1 + 20 kg $ZnSO_4$+10 kg $FeSO_4$	59.12	58.32	58.72	5.43	6.20	5.82
F_{10} = F_1 + 20 kg $ZnSO_4$+20 kg $FeSO_4$	60.85	59.48	60.12	6.01	6.59	6.30
Mean	55.14	53.23	54.18	4.86	5.48	5.17
	SEm±	CD (0.05)		SEm±	CD (0.05)	
Irrigation	0.230	1.402		0.046	0.280	
Nutrients	1.088	3.121		0.089	0.255	
I × N	1.478	NS		0.128	NS	

$FeSO_4$, F_{10} = F_1+20 kg $ZnSO_4$+ 20 kg $FeSO_4$). FYM is common for all the treatments. Soil and plant analysis were carried out by using standard procedures.

Results and Discussion

The pooled data of three years clearly indicates that application of RDF + 7.5 t/ha FYM + 20 kg $ZnSO_4$ + 20 kg $FeSO_4$ recorded significantly higher plant height (83.61 cm), grain yield (23.22 q/ha), straw yield (60.12 q/ha) and water use efficiency (6.30 kg /ha.mm) of wheat over the other treatments. The lowest plant height (76.60 cm), grain yield (15.94 q/ha), straw yield (47.03 q/ha) and water use efficiency (4.33 kg/ha.mm)

Table 2. Average water saving in percentage for the *rabi* wheat crop for the years 2013-14, 2014-15 and 2015-16.

Treatments	Depth of irrigation water (mm)				Saving of water (Percentage)
	2013-14	2014-15	2015-16	Mean	
I_1 = 0.8 IW / CPE	420	375.6	423.8	406.47	–
I_2 = 0.6 IW / CPE	360	315.6	363.8	346.47	17.32

of wheat obtained in RDF+FYM as compared to rest of the treatments (Table 1). Similar results obtained in Maize [3]. This might be due to higher uptake of N (91.82 kg/ha), P (10.90 kg/ha), K (94.83 kg/ha), sulfur (25.34 kg/ha), zinc (235.40 g/ha) and iron (1219.50g/ha) by wheat (Tables 2—4) with application of RDF + FYM + 20 kg $ZnSO_4$ + 20 kg $FeSO_4$ as compared to only RDF + FYM N (63.12 kg/ha), P (7.12 kg/ha), K (67.18 kg/ha), sulfur (12.14 kg/ha), zinc (111.26 g/ha) and iron (638.71 g/ha). Similar results obtained [4] in Okra (Bhendi).

Among the irrigation levels @ 0.8 IW/CPE ratio significantly increased grain yield (19.52 q/ha), straw yield (55.14 q/ha) and water use efficiency (5.48 kg/ha.mm) as compared to 0.6 IW/CPE ratio grain yield (18.86 q/ha) and straw yield (53.23 q/ha) and water use efficiency (5.17 kg/ha.mm). Between two irrigation treatments (0.8 IW/CPE and 0.6 IW/CPE) the average (three years 2013-14, 2014-15 and 2015-16) amount of saving of water is 17.32% with 0.6 IW/CPE ratio.

Significantly more gross return, net return and B:C ratio found with irrigating the crop @ 0.8 IW/CPE ratio as compared to @ 0.6 IW/CPE ratio. Among fer-

Table 3. Effect of irrigation and nutrient levels on nitrogen, phosphorus and potassium uptake by wheat (pooled data of the years 2013-14, 2014-15 and 2015-16).

Treatments	Nitrogen uptake (kg/ha)			Phosphorus uptake (kg/ha)			Potassium uptake (kg/ha)		
	I_1= 0.8 IW/ CPE	I_2 = 0.6 IW/ CPE	Mean	I_1 = 0.8 IW/ CPE	I_2= 0.6 IW/ CPE	Mean	I_1= 0.8 IW/ CPE	I_2= 0.6 IW/ CPE	Mean
F_1 = RDF + FYM	64.07	62.18	63.12	7.17	7.08	7.12	67.89	66.47	67.18
F_2 = F_1+15 kg S/ha (Through gypsum)	71.34	67.83	69.58	8.11	7.75	7.93	75.92	72.33	74.13
F_3 = F_1+10 kg $ZnSO_4$	75.04	73.63	74.34	8.46	8.62	8.54	80.88	78.18	79.53
F_4 = F_1+20 kg $ZnSO_4$	78.59	76.54	77.56	9.07	9.01	9.04	84.32	81.83	83.08
F_5 = F_1+ 10 kg $FeSO_4$	73.28	72.95	73.12	8.67	8.74	8.71	77.63	76.71	77.17
F_6 = F_1+20 kg $FeSO_4$	77.92	76.31	77.12	9.18	9.18	9.18	82.99	80.13	81.56
F_7 = F_1+10 kg $ZnSO_4$+ 10 kg $FeSO_4$/ha	82.61	80.91	81.76	9.75	9.73	9.74	89.25	86.81	88.03
F_8 = F_1+10 kg $ZnSO_4$+ 20 kg $FeSO_4$	84.53	83.57	84.05	10.08	10.09	10.08	90.32	89.63	89.97
F_9 = F_1+20 kg $ZnSO_4$+ 10 kg $FeSO_4$	86.82	86.62	86.72	10.33	10.52	10.42	91.13	91.69	91.42
F_{10} = F_1+20 kg $ZnSO_4$+ 20 kg $FeSO_4$	93.11	90.58	91.82	10.61	11.20	10.90	95.44	94.22	94.83
Mean	78.73	77.11	77.92	9.14	9.19	9.17	83.56	81.80	82.69
	SEm±	CD (0.05)		SEm±	CD (0.05)		SEm±	CD (0.05)	
Irrigation	0.343	NS		0.307	NS		0.633	NS	
Nutrients	1.402	4.027		0.164	0.471		2.123	6.088	
I × N	1.915	NS		0.378	NS		2.918	NS	

Table 4. Effect of irrigation and nutrient levels on sulfur, zinc and iron uptake by wheat (pooled data of the years 2013-14, 2014-15 and 2015-16).

Treatments	Sulfur uptake (kg/ha)			Zinc uptake (g/ha)			Iron uptake (g/ha)		
	I_1 = 0.8 IW/ CPE	I_2 = 0.6 IW/ CPE	Mean	I_1 = 0.8 IW/ CPE	I_2 = 0.6 IW/ CPE	Mean	I_1 = 0.8 IW/ CPE	I_2 = 0.6 IW/ CPE	Mean
F_1 = RDF+FYM	12.32	11.96	12.14	113.34	109.17	111.26	650.69	626.71	638.71
F_2 = F_1+15 kg S/ha (Through gypsum)	19.92	18.96	19.44	129.10	120.44	124.77	722.43	679.42	700.93
F_3 = F_1+10 kg $ZnSO_4$	18.65	18.75	18.70	170.45	167.29	168.87	756.64	730.10	743.37
F_4 = F_1+20 kg $ZnSO_4$	20.49	20.32	20.41	202.29	197.74	200.02	798.69	773.93	786.31
F_5 = F_1+10 kg $FeSO_4$	18.18	18.16	18.17	129.55	129.70	129.63	916.69	911.90	914.30
F_6 = F_1+20 kg $FeSO_4$	19.99	19.88	19.34	139.42	135.00	137.21	1051.60	1021.40	1036.50
F_7 = F_1+10 kg $ZnSO_4$+10 kg $FeSO_4$/ ha	22.11	21.75	21.93	193.88	190.09	191.99	1039.41	1006.95	1023.18
F_8 = F_1+10 kg $ZnSO_4$+20 kg $FeSO_4$	23.09	22.97	23.03	196.88	196.31	196.60	1150.47	1134.68	1142.57
F_9 = F_1+20 kg $ZnSO_4$+ 10 kg $FeSO_4$	23.53	23.85	23.69	222.46	220.80	221.63	1073.65	1066.17	1069.91
F_{10} = F_1+20 kg $ZnSO_4$+ 20 kg $FeSO_4$	25.53	25.14	25.34	237.68	233.12	235.40	1233.14	1205.85	1219.50
Mean	20.38	20.17	20.28	173.51	169.97	171.74	939.34	915.71	927.53
	SEm±		CD (0.05)		SEm±	CD (0.05)	SEm±	CD (0.05)	
Irrigation	0.416		NS		1.146	NS	1.915	11.651	
Nutrients	0.586		1.680		5.332	15.287	25.251	72.397	
1 × N	0.889		NS		7.245	NS	33.932	NS	

tilizer levels significantly more gross return (Rs 48, 800/ha), net return (Rs 22,613/ha) and B:C (1.86) found with application of RDF+ FYM+20 kg $ZnSO_4$ + 20 kg $FeSO_4$ / ha as compared to rest of treatments. Significantly higher gross return (Rs 49,646/ha), net return (Rs 23,290/ha) and B:C ratio (1.88) were obtained with 0.8 W/CPE ratio as compared to 0.6 IW/CPE ratio: Gross return (Rs 47,954/ha), net return (Rs 21,936/ha) and B:C ratio (1.84). Significant differences were noticed in available Zn (0.66 ppm) and Fe (5.93 ppm) with application of RDF+FYM+20 kg $ZnSO_4$+20 kg $FeSO_4$ (Tables 5 and 6) as compared to only RDF + FYM (available Zn 0.51 ppm and available iron 3.83 ppm) after harvest of wheat crop. So it clearly indicated that Zn and Fe build up with application of RDF+FYM+20 kg $ZnSO_4$ + 20 kg $FeSO_4$.

Conclusion

From the present study it could be concluded that

Table 5. Effect of irrigation and nutrient levels on available zinc and iron in soil after harvest of wheat (pooled data of the years 2013-14, 2014-15 and 2015-16).

Treatments	Zinc (ppm)			Iron (ppm)		
	I_1 = 0.8 IW/ CPE	I_2 = 0.6 IW/ CPE	Mean	I_1 = 0.8 IW/ CPE	I_2 = 0.6 IW/ CPE	Mean
F_1 = RDF + FYM	0.48	0.53	0.51	3.27	3.50	3.83
F_2 = F_1 + 15 kg S/ha (Through gypsum)	0.48	0.53	0.51	3.33	3.50	3.42
F_3 = F_1 + 10 kg $ZnSO_4$	0.60	0.62	0.61	3.53	3.43	3.48
F_4 = F_1 + 20 kg $ZnSO_4$	0.63	0.64	0.64	3.67	3.50	3.58
F_5 = F_1 + 10 kg $FeSO_4$	0.51	0.52	0.51	4.73	4.80	4.77
F_6 = F_1 + 20 kg $FeSO_4$	0.52	0.55	0.53	5.87	5.50	5.68
F_7 = F_1 + 10 kg $ZnSO_4$ + 10 kg $FeSO_4$ / ha	0.60	0.62	0.61	5.23	5.10	5.17
F_8 = F_1 + 10 kg $ZnSO_4$ + 20 kg $FeSO_4$	0.63	0.62	0.63	5.90	5.60	5.75
F_9 = F_1 + 20 kg $ZnSO_4$ + 10 kg $FeSO_4$	0.66	0.64	0.65	5.00	4.80	4.90
F_{10} = F_1 + 20 kg $ZnSO_4$ + 20 kg $FeSO_4$	0.67	0.66	0.66	6.00	5.87	5.93
Mean	0.58	0.59	0.59	4.65	4.56	4.61
	SEm±	CD (0.05)		SEm±	CD (0.05)	
Irrigation	0.003	NS		0.052	NS	
Nutrients	0.006	0.017		0.084	0.241	
I × N	0.007	NS		0.124	NS	

Table 6. Effect of irrigation and nutrient levels on gross return (Rs), net return and B:C ratio of wheat (pooled data of the years 2013-14, 2014-15 and 2015-16).

Treatments	Gross return (Rs)			Net return (Rs)			B:C ratio		
	I_1= 0.8 IW/ CPE	I_2 = 0.6 IW/ CPE	Mean	I_1 = 0.8 IW/ CPE	I_2= 0.6 IW/ CPE	Mean	I_1= 0.8 IW/ CPE	I_2= 0.6 IW/ CPE	Mean
F_1 =RDF + FYM	41664	39625	40645	17694	15253	16474	1.74	1.63	1.68
F_2 =F_1+15 kg S/ha (Through gypsum)	45167	42037	43602	18818	16565	17691	1.72	1.65	1.68
F_3 =F_1+10 kg $ZnSO_4$	46925	45970	46448	20726	20104	20416	1.79	1.78	1.79
F_4 =F_1+20 kg $ZnSO_4$	48976	47357	48167	22260	21008	21634	1.83	1.80	1.82
F_5 =F_1+ 10 kg $FeSO_4$	46460	45814	46137	20364	20085	20225	1.78	1.78	1.78
F_6 =F_1+20 kg $FeSO_4$	48689	47451	48070	22313	21442	21877	1.85	1.82	1.84
F_7 = F_1+10 kg $ZnSO_4$+ 10 kg $FeSO_4$/ha	51006	49347	50176	24260	22967	23614	1.91	1.87	1.89
F_8 =F_1+10 kg $ZnSO_4$+ 20 kg $FeSO_4$	52955	51256	52105	26129	24797	25463	1.97	1.94	1.96
F_9 =F_1+20 kg $ZnSO_4$+ 10 kg $FeSO_4$	54735	53569	54152	27739	26940	27339	2.01	2.01	2.01
F_{10} =F_1+20 kg $ZnSO_4$+ 20 kg $FeSO_4$	59882	57107	58495	32606	30198	31401	2.19	2.12	2.16
Mean	49646	47954	48800	23290	21936	22613	1.88	1.84	1.86
	SEm±	CD (0.05)		SEm±	CD (0.05)		SEm±	CD (0.05)	
Irrigation	119.16	725.03		113.74	692.03		0.004	0.025	
Nutrients	749.71	2149.45		765.46	2194.61		0.027	0.079	
I × N	1012.87	NS		1033.25	NS		0.037	NS	

the application of RDF + 7.5 t/ha FYM+ 20 kg $ZnSO_4$ + 20 kg $FeSO_4$/ha recorded significantly higher plant height, grain yield, straw yield, water use efficiency, gross return, net return and B:C ratio of wheat over rest of the treatments under irrigated condition.

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