

Effect of Copper Sulfate Application on Content and Uptake of Other Micronutrients in Onion (*Allium cepa* L.)

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Abstract Field experiments were conducted at farmer fields in Vadivellampalayam and Panaiyampalli villages in Tamil Nadu during *rabi* season 2012 for study the effect of copper sulfate application on content and uptake of micronutrients in onion. The experiment was laid out in a randomized block design replicated thrice with seven levels of Cu application viz., 0, 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 kg ha⁻¹ along with recommended fertilizer dosage 60 : 60 : 30 kg N, P₂O₅ and K₂O kg ha⁻¹. Effect of copper sulfate on micronutrients viz., Fe, Mn, and Zn content in onion plant (both leaf and bulb) was decreased with increasing doses of Cu application in both stages (bulb initiation and harvest) of onion, however the uptake was increased with copper application up to 1.5 kg Cu ha⁻¹ and thereafter the additional dose of Cu decreased the uptake of nutrients. Soils having higher available status of DTPA-Cu are less responsive to applied copper and lower amount of DTPA-Cu in soils are highly responsive in terms of increasing growth parameters and yield and its attributes.

Keywords Copper sulfate, Micronutrients, Nutrient content, Nutrient uptake, Onion bulb, Onion leaf.

Introduction

Onion (*Allium cepa* L.) is an important vegetable and a famous spice commodity of Alliaceae family grown all over the world and consumed in various forms. Copper as an essential micronutrient for normal growth and metabolism of plants. Onion belongs to a group of vegetables that have high response to Cu [1]. Cu²⁺ is a component of large number of proteins and enzymes like plastocyanin, diamine oxidase, polyphenol oxidase, ascorbate oxidase. Copper containing enzymes play important roles in photosynthesis, respiration, and formation of lignin. Inadequate copper levels lead to reduced starch production, reduced nodulation and nitrogen fixation in legumes, delayed flowering, maturity and pollen sterility, imparting disease resistance, enhancing fertility of male flowers. Onion is highly responsive to Cu, application of CuSO₄ increased the yield of fresh onion bulbs to the tune of 18.3% over control [2]. Copper deficiency limited the activity of many plant enzymes viz., ascorbate oxidase, phenolase, cytochrome oxidase, diamine oxidase, plastocyanin, and superoxide dismutase. The deficiency symptoms of copper are chlorosis, stunted growth, twisted young leaves, withered leaf tips and wilting [3]. Many interactions among these micronutrients may also occur. Studies have shown that Cu and Zn interact with each other due to antagonistic relationship as Cu–Zn antagonism has been suggested by many workers [4]. Hence the present investigation was undertaken to study the response of onion to Cu fertilization in the field conditions.

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Materials and Methods

Field experiments were conducted at two locations in farmer fields in Vadivellampalayam and Panaiyampalli villages in Tamil Nadu during *rabi* season 2012 for study the effect of copper sulfate application on content and uptake of micronutrients in onion. The soil of the experimental fields was belonging to the soil series Vellalur and Palathurai. The initial analysis of experimental soil was neutral to slightly alkaline in reaction and with free from salts. The organic carbon content of the soil was low. The available nutrient status of the soil was low in available N and P, medium in available K. The soil was sufficient in DTPA Zn, Mn, Fe and Hot Water Soluble Boron. The experiment was laid out in a randomized block design replicated thrice with seven levels of Cu application viz., 0, 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 kg ha⁻¹ along with recommended fertilizer dosage 60 : 60 : 30 kg N, P₂O₅ and K₂O kg ha⁻¹. The fertilizers were applied in the form of urea, super phosphate and muriate of potash to all the treatments. Before sowing of onion bulbs, the required quantity of Cu was applied through CuSO₄ as per the schedule. Plant samples viz., leaves, bulbs were collected at two stages viz., bulb initiation and harvest stages. The collected plant samples were shade dried and then kept in a hot air oven at 70°C and ground in a Willey Mill. The processed plant samples were digested with diacid mixture in block digester and getting the white solution were analyzed for total nutrient content of Zn, Fe, Mn by with help of AAS. The nutrient uptake was calculated with yield and content of nutrient for each treatment separately.

Results and Discussion

Nutrient content

Cu content in leaves and bulbs

The Cu concentration in leaves and bulbs were significantly influenced by various levels of Cu treatments both at bulb initiation and harvest stages. The leaf copper ranged from 8.0 mg/kg to 11.35 mg/kg and 7.1 mg/kg to 9.3 mg/kg at bulb initiation and harvest stage respectively. The bulb Cu content ranged from 7.35 to 9.1 mg kg⁻¹ and 6.2 to 8.7 mg kg⁻¹ at bulb initia-

tion and harvest stages (Table 1). Among the various levels of Cu application treatments, treatment T₄ (100% RDF of NPK + 1.5 kg Cu ha⁻¹) recorded the highest pooled mean Cu concentration of 9.10 and 8.7 mg kg⁻¹ during bulb initiation and harvest stages of onion bulbs. The lowest concentration of Cu was noticed in control treatment both at bulb initiation and harvest and the Cu concentration was higher in bulb initiation stage of onion crop in all treatments as compared to harvest stage. This was in accordance with the reports of Kumar et al. [5].

Zn content in leaves and bulb

Zinc content in leaves was significantly influenced due to different doses of Cu in varied available Cu soils. Among all treatments control (100% RDF of NPK) had the highest amount of Zn concentration in leaves and bulbs both at bulb initiation and harvest stages and lowest was noticed in treatment T₇ (100% RDF of NPK + 3.0 kg Cu) in both locations (Table 1). The application rate of Cu increases decreased the Zn contents in leaf and bulbs due to antagonism effect at the adsorption sites in the plasma lemma or at the adsorption sites at cell wall. Cu and Zn both cationic micronutrients are competitive at absorption sites on root surface, in higher concentration of copper condition reduces the absorption of zinc ion through roots ; automatically the nutrient content would decrease. The antagonistic effect of Cu and Zn on nutrient content in plants has been well documented by Dangarwala [4] and Kumar et al. [5] in wheat.

Fe content in leaves and bulbs

Iron content in leaves and bulbs were decreased significantly with graded level of applied in varied initial available Cu soils at both bulb initiation and harvest stages. The magnitude of reduction in Fe content in leaf was 13.8 to 16.0% at bulb initiation stage 14.1 to 17.3% at harvest stage with the application of 3.0 mg kg⁻¹ Cu over control (Table 2). Comparison of iron content in leaf and bulb, less amount of iron concentration was present in bulb, due to more amount of production and accumulation of iron containing enzymes and proteins in leaves. The reduced in Fe content both in leaf and bulbs were noticed with increas-

Table 1. Effect of different levels of Cu application on Cu and Zn content (mg kg⁻¹) of onion leaves and bulb at bulb initiation and harvest stage.

Treatments	Onion leaf (Cu content)						Onion bulb (Cu content)					
	Bulb initiation			Harvest stage			Bulb initiation			Harvest stage		
	L ₁	L ₂	Mean	L ₁	L ₂	Mean	L ₁	L ₂	Mean	L ₁	L ₂	Mean
T ₁	7.80	8.20	8.00	7.10	7.10	7.10	7.10	7.60	7.35	5.90	6.50	6.20
T ₂	8.10	8.70	8.40	7.50	7.60	7.55	7.40	8.00	7.70	6.40	6.80	6.60
T ₃	10.70	10.80	10.75	8.90	8.90	8.90	8.80	8.60	8.70	8.30	8.40	8.35
T ₄	11.30	11.40	11.35	9.30	9.30	9.30	9.10	9.10	9.10	8.70	8.70	8.70
T ₅	10.30	10.20	10.25	8.60	8.70	8.65	8.50	8.40	8.45	7.50	7.90	7.70
T ₆	9.70	9.50	9.60	8.30	8.30	8.30	8.20	8.30	8.25	7.30	7.50	7.40
T ₇	9.30	8.90	9.10	7.90	8.20	8.05	7.70	8.10	7.90	6.70	7.00	6.85
Mean	9.60	9.70		8.20	8.30		8.10	8.30		7.30	7.60	
SEd	0.08	0.06		0.04	0.04		0.04	0.07		0.19	0.06	
CD at 5%	0.19	0.14		0.09	0.10		0.10	0.16		0.42	0.13	

Table 1. Continued.

Treatments	Onion leaf (Zn content)						Onion bulb Zn content					
	Bulb initiation			Harvest stage			Bulb initiation			Harvest stage		
	L ₁	L ₂	Mean	L ₁	L ₂	Mean	L ₁	L ₂	Mean	L ₁	L ₂	Mean
T ₁	10.38	10.10	10.24	8.18	8.00	8.09	12.08	11.91	11.99	9.98	9.81	9.90
T ₂	10.29	10.15	10.22	7.99	7.85	7.92	12.00	11.97	11.98	9.80	9.67	9.74
T ₃	10.22	10.01	10.11	7.82	7.71	7.76	11.98	11.70	11.84	9.58	9.40	9.49
T ₄	10.20	10.01	10.10	7.7	7.61	7.65	11.87	11.59	11.73	9.37	9.19	9.28
T ₅	10.02	9.94	9.98	7.32	7.34	7.33	11.55	11.53	11.54	9.15	8.93	9.04
T ₆	9.96	9.78	9.87	7.16	7.08	7.12	11.66	11.42	11.54	8.96	8.72	8.84
T ₇	9.59	9.63	9.61	6.89	6.83	6.86	11.51	11.14	11.32	8.71	8.34	8.53
Mean	10.09	9.95		7.58	7.49		11.81	11.61		9.36	9.15	
SEd	0.01	0.01		0.012	0.012		0.01	0.01		0.012	0.012	
CD at 5%	0.02	0.02		0.026	0.027		0.02	0.03		0.025	0.027	

ing level of Cu during bulb initiation to harvest stages. The increased in concentration of copper might be antagonistic effect of Cu and Fe on nutrient content in plants which affects the translocation of Fe from roots to the leaves [5].

Mn content in leaves and bulbs

The Cu ions have same ionic radius and valence with Mn ions, so both would competitive in absorption. The concentration of Mn in leaves and bulbs were higher at lower levels of Cu and significantly decreased at higher levels of Cu in both locations at bulb initiation and harvest stages (Table 2). The Mn concentration in leaves and bulbs were decreased from bulb initiation to harvest stage in all treatments.

The increasing the Cu doses in soil, reduced the Mn concentration in both in leaves and bulbs which might be antagonistic effect of Cu and Fe on nutrient content in plants. The similar results reported by Kumar et al. (5) in wheat.

Nutrient uptake in plant samples

Cu uptake in leaves and bulbs

The Cu uptake in bulbs ranged from 3.5 to 6.2 and 7.45 to 17.6 g ha⁻¹ at bulb initiation and harvest stages respectively. The uptake of Cu in onion bulbs was increased from bulb initiation to harvest stages in both locations. Among the different treatments, T₄ (100% RDF of NPK + 1.5 kg Cu ha⁻¹) registered the

Table 2. Effect of different levels of Cu application on Fe and Mn content (mg kg⁻¹) of onion leaves and bulb at bulb initiation and harvest stage.

Treatments	Onion leaf (Fe content)						Onion bulb (Fe content)					
	Bulb initiation			Harvest stage			Bulb initiation			Harvest stage		
	L ₁	L ₂	Mean	L ₁	L ₂	Mean	L ₁	L ₂	Mean	L ₁	L ₂	Mean
T ₁	116.6	113.9	115.25	111.3	108.6	109.95	83.4	80.1	81.75	78.1	74.8	76.45
T ₂	115.7	111.0	113.35	110.2	105.2	107.70	80.1	77.9	79.00	74.3	72.1	73.20
T ₃	110.6	109.3	109.95	104.6	103.5	104.05	78.4	76.1	77.25	72.6	70.3	71.45
T ₄	108.8	104.4	106.60	102.5	98.4	100.45	76.2	74.9	75.55	70.2	68.9	69.55
T ₅	104.5	101.9	103.20	98.5	95.4	96.95	75.0	73.3	74.15	68.5	66.8	67.65
T ₆	102.5	100.4	101.45	95.7	93.6	94.65	73.1	71.3	72.20	66.3	64.5	65.40
T ₇	100.4	98.2	99.30	93.4	91.2	92.30	71.2	69.1	70.15	64.2	62.1	63.15
Mean	108.4	105.6		102.3	99.4		76.7	74.6		70.6	68.5	
SEd	0.31	0.28		0.15	0.17		0.20	0.18		0.11	0.10	
CD at 5%	0.67	0.63		0.33	0.38		0.44	0.40		0.25	0.23	

Table 2. Continued.

Treatments	Onion leaf (Mn content)						Onion bulb (Mn content)					
	Bulb initiation			Harvest stage			Bulb initiation			Harvest stage		
	L ₁	L ₂	Mean	L ₁	L ₂	Mean	L ₁	L ₂	Mean	L ₁	L ₂	Mean
T ₁	22.5	22.3	22.4	20.40	20.20	20.30	7.70	6.30	7.00	12.80	12.50	12.50
T ₂	22.2	22.1	22.15	20.00	19.80	19.90	8.30	6.90	7.60	12.70	12.10	12.10
T ₃	22.0	21.1	21.55	19.60	18.80	19.20	9.80	8.30	9.05	11.90	11.50	11.50
T ₄	21.3	20.2	20.75	18.80	17.80	18.30	10.70	8.50	9.60	11.70	11.30	11.30
T ₅	20.0	19.0	19.50	17.60	16.40	17.00	8.80	7.20	8.00	11.10	10.30	10.30
T ₆	19.9	18.5	19.20	17.20	15.80	16.50	8.40	7.10	7.75	10.70	10.00	10.00
T ₇	19.3	18.0	18.65	16.50	15.20	15.85	7.40	6.20	6.80	10.60	9.60	9.60
Mean	21.0	20.2		18.60	17.70		8.70	7.20		11.60	11.10	
SEd	0.08	0.09		0.21	0.10		0.05	0.05		0.11	0.09	
CD at 5%	0.18	0.19		0.47	0.23		0.12	0.12		0.24	0.20	

highest mean Cu uptake during bulb initiation and harvest stages followed by treatment T₃ (100% RDF of NPK + 1.5 kg Cu ha⁻¹) in onion leaves and bulbs (Table 3). The lowest Cu uptake was noticed in control (100% RDF of NPK) at critical and harvest stage in onion leaves and bulbs. The uptake of copper in leaves and bulb were decreased from bulb initiation to harvest stages in all treatments. Manchanda et al. [6] reported application of copper sulfate through soil significantly increased the copper uptake by soybean straw. Similar results found by Agarwal et al. [7] in tomato.

Zn uptake in leaves and bulbs

The uptake of Zn in onion leaves and bulbs were influenced significantly by copper application. Higher Zn uptake was noticed in treatment T₄ (RDF of NPK

fertilizer + 1.5 kg Cu ha⁻¹) at both locations but higher uptake was observed at location 1 comparison to locations 2 due to the optimum available Cu. The Zn uptake in onion leaves and bulbs were increased from bulb initiation to harvest stages (Table 3). The highest amounts of translocation and accumulation of photosynthates are at harvest stage as compared to bulb initiation stage might have increased Zn content and uptake in harvest of onion crop. Gupta and Singh [8] suggested that the increases in Zn uptake of with Cu in wheat. Increase the uptake of Zn in onion leaves and bulbs at optimum amount of copper application level might be due to the growth of roots.

Fe uptake in leaves and bulbs

Uptake of Fe was increased by copper application up to certain extent after that copper dose increases up-

Table 3. Effect of different levels of Cu application on Cu and Zn uptake (g ha^{-1}) of onion leaves and bulb at bulb initiation and harvest stage.

Treatments	Onion leaf (Cu uptake)						Onion bulb (Cu uptake)					
	Bulb initiation			Harvest stage			Bulb initiation			Harvest stage		
	L ₁	L ₂	Mean	L ₁	L ₂	Mean	L ₁	L ₂	Mean	L ₁	L ₂	Mean
T ₁	2.60	3.00	2.80	7.00	6.90	6.95	3.70	3.30	3.50	8.00	6.90	7.45
T ₂	4.40	4.00	4.20	8.60	8.50	8.55	4.20	3.80	4.00	12.00	13.40	12.70
T ₃	6.60	5.50	6.05	11.60	12.00	11.80	6.00	5.20	5.60	16.70	16.70	16.70
T ₄	8.30	6.40	7.35	13.20	12.90	13.05	6.80	5.60	6.20	17.80	17.40	17.60
T ₅	6.10	4.90	5.50	11.00	11.20	11.10	5.60	4.70	5.15	15.00	15.00	15.00
T ₆	5.60	4.50	5.05	10.30	10.40	10.35	5.10	4.60	4.85	14.20	13.90	14.05
T ₇	5.30	4.10	4.70	9.40	9.90	9.65	4.20	4.10	4.15	12.80	12.60	12.70
Mean	5.50	4.60		10.2	10.3		5.10	4.50		13.8	13.7	
SEd	0.47	0.30		0.23	0.51		0.12	0.30		0.23	0.25	
CD at 5%	1.03	0.67		0.52	1.11		0.27	0.66		0.51	0.54	

Table 3. Continued.

Treatments	Onion leaf (Zn uptake)						Onion bulb Zn uptake					
	Bulb initiation			Harvest stage			Bulb initiation			Harvest stage		
	L ₁	L ₂	Mean	L ₁	L ₂	Mean	L ₁	L ₂	Mean	L ₁	L ₂	Mean
T ₁	3.43	3.74	3.59	8.83	7.68	8.26	6.30	5.10	5.70	13.60	10.40	12.00
T ₂	5.56	4.67	5.12	9.11	8.79	8.95	6.70	5.80	6.25	18.40	19.20	18.80
T ₃	6.34	5.11	5.73	10.17	10.41	10.29	8.20	7.00	7.60	19.30	18.60	18.95
T ₄	7.45	5.71	6.58	10.93	10.58	10.76	8.90	7.20	8.05	19.10	18.40	18.75
T ₅	5.91	4.77	5.34	9.37	9.47	9.42	7.50	6.50	7.00	18.10	16.90	17.50
T ₆	5.68	4.69	5.19	8.88	8.85	8.87	7.40	6.40	6.90	17.40	16.10	16.75
T ₇	5.47	4.43	4.95	8.27	8.26	8.27	6.30	5.60	5.95	16.60	14.90	15.75
Mean	5.69	4.73		9.36	9.15		7.30	6.20		17.50	16.40	
SEd	0.05	0.03		0.021	0.026		0.04	0.03		0.06	0.07	
CD at 5%	0.12	0.06		0.046	0.058		0.1	0.07		0.12	0.16	

take of iron decreases, it might be due to toxicity of copper in plants at higher dosage of copper application (in treatment T₅ to T₇). Among the different levels of Cu application, treatment T₄ (100% RDF of NPK + 1.5 kg Cu ha⁻¹) at bulb initiation (51.8 g ha⁻¹) and harvest (140.5 g ha⁻¹) stages, followed by T₃ (100% RDF of NPK + 1.0 kg Cu ha⁻¹) at both critical (62.5 g ha⁻¹) and harvest (137.85 g ha⁻¹) stages, registered the highest mean of Fe uptake in bulbs (Table 4). The lowest Fe uptake was noticed in control treatment both at critical (34.5 g ha⁻¹) and harvest (87.6 g ha⁻¹) stages. Fe and Cu were cationic micronutrients competitive for absorption on soil absorption sites, due to this released the Fe²⁺ ions form solid phase and increases the concentration of Fe²⁺ ions to solution. These findings are in accordance with Venugopal [9] in cauliflower.

Mn uptake in leaves and bulbs

At both bulb initiation and harvest stages, manganese uptake in onion leaves and bulbs were influenced significantly the copper application. The uptake of Mn was increased from bulb initiation stage to harvest (Table 4). Copper application increases the Mn uptake by plant in certain extent after that decrease with increases in application of copper. These are due to toxicity of copper in onion plant at higher dosages and stunt the growth of the plant at higher concentration as reported by Chew et al. [10] in groundnut. Raghupathi [11] opined that Cu gets adsorbed on soil constituents with the concomitant release of other cations such as Mn and are most active in the adsorption of Cu. Increasing in uptake of nutrient in plant with application other nutrient

Table 4. Effect of different levels of Cu application on Fe and Mn uptake (g ha^{-1}) of onion leaves and bulb at bulb initiation and harvest stage.

Treatments	Onion leaf (Fe uptake)						Onion bulb (Fe uptake)					
	Bulb initiation			Harvest stage			Bulb initiation			Harvest stage		
	L ₁	L ₂	Mean	L ₁	L ₂	Mean	L ₁	L ₂	Mean	L ₁	L ₂	Mean
T ₁	38.50	42.10	40.30	120.20	104.30	112.25	43.40	34.40	38.90	106.20	79.30	92.75
T ₂	62.50	51.10	56.80	125.60	117.80	121.70	44.90	37.40	41.15	139.70	142.80	141.25
T ₃	68.60	55.70	62.15	136.00	139.70	137.85	53.30	45.70	49.50	145.90	139.20	142.55
T ₄	79.40	59.50	69.45	145.60	136.80	141.20	57.20	46.40	51.80	143.20	137.80	140.50
T ₅	61.70	48.90	55.30	126.10	123.10	124.60	48.80	41.00	44.90	135.60	126.30	130.95
T ₆	58.40	48.20	53.30	118.70	117.00	117.85	46.10	39.90	43.00	128.60	119.30	123.95
T ₇	57.20	45.20	51.20	111.20	110.40	110.80	39.20	34.60	36.90	122.60	111.20	116.90
Mean	60.9	50.1		126.2	121.3		47.5	39.9		131.7	122.3	
SEd	0.6	0.29		0.27	0.31		0.30	0.23		0.40	0.54	
CD at 5%	1.32	0.63		0.60	0.68		0.65	0.51		0.87	1.17	

Table 4. Continued.

Treatments	Onion leaf (Mn uptake)						Onion bulb (Mn uptake)					
	Bulb initiation			Harvest stage			Bulb initiation			Harvest stage		
	L ₁	L ₂	Mean	L ₁	L ₂	Mean	L ₁	L ₂	Mean	L ₁	L ₂	Mean
T ₁	7.40	8.30	7.85	22.00	19.40	20.70	4.00	2.70	3.35	17.40	13.30	15.35
T ₂	12.00	10.20	11.10	22.70	22.20	22.45	4.60	3.30	3.95	23.90	24.00	23.95
T ₃	13.60	10.80	12.20	25.40	25.40	25.40	6.70	5.00	5.85	23.90	22.80	23.35
T ₄	15.60	11.50	13.55	26.70	24.80	25.75	8.00	5.30	6.65	23.90	22.60	23.25
T ₅	11.80	9.10	10.45	22.60	21.10	21.85	5.70	4.00	4.85	22.00	19.50	20.75
T ₆	11.30	8.90	10.10	21.30	19.80	20.55	5.30	4.00	4.65	20.80	18.50	19.65
T ₇	11.00	8.30	9.65	19.60	18.40	19.00	4.10	3.10	3.60	20.20	17.20	18.70
Mean	11.8	9.60		22.9	21.6		5.50	3.90		21.7	19.7	
SEd	0.12	0.06		0.06	0.06		0.79	0.64		0.12	0.34	
CD at 5%	0.27	0.13		0.13	0.14		1.74	1.40		0.26	0.73	

indicates the positive function of growth in plants with applied nutrient.

Conclusion

Effect of copper sulfate on micronutrients viz., Fe, Mn, and Zn content in onion plant (both leaf and bulb) was decreased with increasing doses of Cu application in both stages (bulb initiation and harvest) of onion, however the uptake was increased with copper application upto $1.5 \text{ kg Cu ha}^{-1}$ and thereafter the additional dose of Cu decreased the uptake of nutrients. Soils having higher available status of DTPA–Cu are less responsive to applied copper and lower amount of DTPA–Cu in soils are highly responsive in terms of increasing growth parameters and yield and its attributes.

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