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Effect of sulphur and zinc on growth and yield of kharif onion (*Allium cepa* L.)

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Abstract
A field experiment was laid down to evaluate effect of Sulphur and Zinc of growth and yield of onion. Experiment was carried out during *kharif* season of 2018-19 at Horticulture farm, College of Agriculture, Sehore RVSKVV, Gwalior in factorial randomized block design with three replications. The experiment was comprised of ten treatments *viz*., T_1: 0 Kg Sha-1, T2: 18.75 Kg Sha^{-1}, T_3: 37.50 Kg Sha^{-1}, T_4: 56.25 Kg Sha^{-1}, T_5: 75 Kg Sha^{-1}, T_6: 0 Kg (Zinc EDTA 12%) ha^{-1}, T_7: 2.5Kg (Zinc EDTA 12%) ha^{-1}, T8: 5 Kg (Zinc EDTA 12%) ha^{-1}, T_9: 7.5 Kg (Zinc EDTA 12%) ha^{-1}, T_{10}: 10 Kg (Zinc EDTA 12%) ha^{-1}.
Observation recorded on Growth attributing Characters *viz*., plant height, no. of leaves per plant, leaf length per plant, and leaf width per plant recorded at 30, 60 and 90 DAT; Yield attributing characters *viz*., no. of bolting per plant, neck thickness, equatorial diameter, polar diameter of bulb, No. of scales per bulb, Girth of bulb, Dry matter of tops per hectare fresh weight of bulb, bulb yield per plot, bulb yield per hectare. Present study revealed beneficial effect of sulphur and zinc on growth and yield of onion.

Keywords: Onion, sulphur, zinc, bulb yield

Introduction
Onion (*Allium cepa* L.) is a bulbous biennial herb of amaryllidaceae family. Onion is a vegetable and spice crop cultivated commercially almost all the countries of the world and consumed across the globe. The produce of *rabi* season is stored for consumption in summer and *kharif*, but due to lack of proper storage condition and losses due to spoilage in the *monsoon* season and the prices goes up. Hence, production of onion during *kharif* is required to fill up the gap of demand and supply.
In recent years, sulphur deficiency is becoming widespread due to continuous use of sulphur free fertilizers, high yielding varieties and intensive cropping of high sulphur requiring crops. Leaching and erosion losses also contribute to sulphur deficiency.
Sulphur is an essential constituent of certain amino acids namely cysteine, cystine and methionine and involved in synthesis of protein and sulphur bearing vitamins like biotine, thiamine and some coenzymes. It is also a constituent of allyl propyl disulphide, which imparts the specific pungency to onion. It is involved in the formation of chlorophyll that permits photosynthesis. On the other hand, sulphur deficiency may be responsible for cupping of leaves, reddening of stems and petiole and stunted growth. Therefore, adequate attention should be paid to sulphur fertilization.
Zinc is an essential micronutrient, which has become increasingly important in agricultural production during the past two decades. It plays an important role in various enzymatic and physiological activities of the plants.

Materials and Methods
The investigation was carried out at research field, department of Horticulture, College of Agriculture, Sehore campus of RVSKVV, Gwalior during *kharif* season 2016-17. The experiment was comprised of ten treatments *viz*., The experiment was comprised of ten treatments *viz*., T_1: 0KgSha^{-1}, T_2: 18.75 KgSha^{-1}, T_3: 37.50 KgSha^{-1}, T_4: 56.25 KgSha^{-1}, T_5: 75 KgSha^{-1}, T_6: 0 Kg (Zinc EDTA 12%)ha^{-1}, T_7: 2.5Kg (Zinc EDTA 12%) ha^{-1}, T_8: 5 Kg (Zinc EDTA 12%) ha^{-1}, T_9: 7.5 Kg (Zinc EDTA 12%)ha^{-1}, T_{10}: 10 Kg (Zinc EDTA 12%)ha^{-1}. Experiment was laid out in Factorial Randomized Completely Block Design with three replications. Full dose of phosphorus, potash and ½ dose of nitrogen were applied.
Full quantity of phosphorus and potash along with one third of nitrogen was applied as per treatment plot before transplanting the seedling. While, the rest of the nitrogen was applied in two equal splits doses at 25 and 50 days after transplanting.

Well decomposed FYM was incorporated in soil as basal dose. Transplanting of healthy seedlings was done with spacing of 60cm × 45cm. All cultural operations were done as per recommendations. Observations were recorded from five random healthy plants of each treatment on growth, yield and its attributes. The experimental data recorded were subjected to statistical analysis using analysis of variance technique suggested by Panse and Sukhtame (1984).

Results and Discussion

Growth parameters

The data (Table 1 and Table 2) for Growth parameters *viz*., plant height, no. of leaves per plant, leaf length per plant, and leaf width per plant recorded at 30, 60 and 90 DAT.

The average plant height recorded in between 29.13 cm to 37.40 cm at 30 DAT. Treatment T_9 recorded significantly maximum plant at 30DAT which is at par with treatment T_2 while lowest plant height found in treatment T_{10}. At 60 DAT the average plant height recorded in between 45.26 cm to 55.80 cm. Treatment T_{10} observed maximum plant height at which is at par with treatment T_9 and treatment T_5. Lowest plant height found maximum in treatment T_1 at 60 DAT. At 90 DAT the average plant height recorded in between 53.93cm to 62.60cm. Treatment T_{10} observed maximum plant height at which is at par with treatment T_9 and treatment T_5. Lowest plant height found maximum in treatment T_1 at 90 DAT. Similar results were reported by Dake *et al.* (2011) [3].

The average number of leaves per plant recorded in between 4.86 to 6.06 At 30 DAT. Maximum numbers of leave per plant recorded in treatment T_{10} which is significantly at par with T_5 while lowest height observed in T_6 at 30 DAT. At 60 DAT the average number of leaves per plant recorded in between 7.06 to 10.53. Maximum number of leaves found in treatment T_{10} which is significantly at par with T_5 treatment and lowest in treatment T_1. At 90 DAT the average number of leaves per plant recorded in between 10.00 to 12.53. Treatment T_{10} registered maximum number of leaves per plant followed by T_5, T_9, T_4 and T_8. Minimum leaves per plant observed in treatment T_1 at 90 DAT. Similar results were reported by Dake *et al.* (2011) [3], Acharya *et al.* (2015) [2].

The average leaf length per plant recorded between 28.53 cm to 36.33 cm at 30 DAT. It is found highly significant and it is followed by T_{10} [10 kg (zinc EDTA 12%)ha^{-1}] (36.33 cm), T_9 [7.5kg (zinc EDTA12%)ha^{-1}] (33.83 cm), T_5 (75kgSha^{-1}) (33.53 cm), T_4 (56.25kgSha^{-1}) (33.06 cm.), T_8 [5kg(zinc EDTA 12%)ha^{-1}] (32.80 cm.) and lowest in control T_1 (28.53 cm). At 60 DAT the average leaf length per plant recorded between 37.26 cm to 47.40 cm. It is found highly significant and at par with T_{10} [10kg (zinc EDTA 12%) ha^{-1}] (55.80 cm), T_5 (75kgSha^{-1}) (46.33c.m) T9 [7.5kg (zinc EDTA12%) ha^{-1}] (45.20 cm), and lowest in control T_1 (45.26 cm). At 90 DAT the average leaf length per plant recorded between 43.93cm to 52.73 cm. it is found highly significant and it is followed by T_{10} [10kg (zinc EDTA 12%) ha^{-1}] (52.73 cm), T_9 [7.5kg (zinc EDTA 12%)ha^{-1}] (51.26 cm), T_5 (75kgSha^{-1}) (50.60c.m), T_4 (56.25kgSha^{-1}) (49.33cm.), T_8 [(zinc EDTA 12%)ha^{-1}] (39.26cm.) and lowest in control T_1 (43.93 cm.)

Leaf width per plant recorded in between 0.38 cm to 0.80 cm at 30 DAT. Leaf width per plant recorded in treatment T_{10} (6.33) while lowest leaf width (0.38) observed in T_1 at 30 DAT. But it did not influence by Sulphur and Zinc. At 60 DAT the average number of leaf per plant recorded between 0.64 cm to 0.85 cm. Maximum leaf width found in treatment T_{10} followed by T_5, T_9 and T_8 treatment whereas lowest in treatment T_1. At 90 DAT the leaf width per plant recorded in between 0.76 cm to 1.17 cm. Treatment T_{10} registered maximum number of leaves per plant followed by T_9, T_5, T_4 and T_8. Minimum leaves per plant observed in treatment T_1 at 90 DAT. Similar results were reported by Dake *et al.*, (2011), Abedin *et al.*, (2012) [3, 1].

Table 1: Effect of different treatments of plant height and no of leaves plant^{-1} at different stages

Treat. Symb.	Plant height (cm) at			No. of leaves per plant at			Leaf length (cm) at		
	30DAT	60DAT	90DAT	30DAT	60DAT	90DAT	30 DAT	60DAT	90 DAT
T_1	31.40	45.26	53.93	5.20	7.06	10.00	28.53	37.26	43.93
T_2	34.13	46.70	56.33	5.40	8.00	10.53	30.60	38.53	46.80
T_3	32.80	50.13	58.08	5.53	8.40	11.16	31.46	40.80	48.53
T_4	33.33	51.26	60.80	5.66	8.93	11.66	33.06	43.33	49.33
T_5	32.80	52.86	62.00	5.93	9.73	12.06	33.53	46.33	50.60
T_6	33.06	46.13	54.73	4.86	7.80	10.40	30.40	38.43	44.86
T_7	33.13	47.93	57.40	5.46	8.26	10.93	31.86	40.60	47.93
T_8	33.06	49.40	59.60	5.53	8.56	11.26	32.80	42.20	49.26
T_9	37.70	52.46	61.40	5.60	9.13	11.93	33.83	45.20	51.26
T_{10}	29.13	55.80	62.60	6.06	10.53	12.53	36.33	47.40	52.73
S.Em±	1.25	1.29	0.55	0.129	0.34	0.11	0.34	0.78	0.36
C.D. 5% level	3.74	3.85	1.66	0.38	1.02	0.34	1.03	2.32	1.09

Table 2: Effect of different treatments of leaf length and leaves width at different stages

Treat. Symb.	Leaves width (cm) at			Number of bolting plot^{-1}	Bolting %
	30DAT	60 DAT	90DAT		
T_1	0.38	0.64	0.76	22.73	8.99
T_2	0.44	0.69	0.86	14,06	5.80
T_3	0.45	0.72	0.92	21.00	8.36
T_4	0.46	0.77	0.94	20.00	7.92
T_5	0.47	0.80	0.97	18.46	7.33
T_6	0.38	0.67	0.82	15.70	6.20
T_7	0.42	0.72	0.93	19.00	7.58
T_8	0.43	0.77	0.96	18.80	7.17
T_9	0.46	0.79	1.04	18.93	7.26
T_{10}	0.80	0.85	1.17	13.93	5.42
S.Em±	0.09	0.01	0.007	0.89	0.57
C.D. 5% level	NS	0.03	0.023	2.64	1.71

Yield parameters: The Data (Table 3 and Table 4) related to Yield attributing characters *viz*, no. of bolting per plant, neck thickness, equatorial diameter, polar diameter of bulb, No. of scales per bulb, Girth of bulb, Dry matter of tops per hectare fresh weight of bulb, bulb yield per plot, bulb yield per hectare, varied significantly due to treatments.

Number of bolting per plot varied to 13.93 cm to 22.33 cm. Maximum bolting per plot recorded treatment T_1 control plot (22.33 cm) which is significantly at par with treatment T_3 (S2 37.5kgSha^{-1}) (21.00cm.) and lowest no. of bolting per plot observed in treatment in T_{10} [10kg (Zinc EDTA 12%)ha^{-1}] (13.93cm). Similar results were reported by Deb *et al.*, (2009) [4].

Neck thickness of bulb recorded in between 0.48 to 0.84 cm. It is found highest in treatment T_8 [5kg (zinc EDTA 12%)ha^{-1}] (0.84 cm), which is significantly at par with treatment T_7 [Zn1 [2.5kg (zinc EDTA 12%)ha^{-1}] (0.81 cm), control T_6 (0.76 cm), T_9 [7.5kg (zinc EDTA12%)ha^{-1}] (90.75 cm), T_5 (75kgSha^{-1}) (0.72 cm), T_4 (56.25kg S ha^{-1}) (0.68 cm.), T_{10} [Zn4 10kg(zinc EDTA 12%)ha^{-1}] (0.62cm). Treatment T_1 registered minimum (0.48 cm) Neck thickness of bulb. Similar results were reported by Rizk *et al.*, (2012), Mishu *et al.*, (2013) [11, 7].

The maximum equatorial diameter of bulb was found with the treatment T_{10} [10kg (zinc EDTA 12%) ha^{-1}] (6.33cm) and minimum was with the treatment T_5 (75kgSha^{-1}) (5.27). But it did not significantly influence by the Sulphur and Zinc. Similar results were reported by Dab *et al.* (2009) [4].

The polar diameter of bulb was found the maximum in treatment T_{10} [10kg (zinc EDTA 12%) ha^{-1}] (5.48cm) and minimum was with the treatment T_1 (control plot) (4.23). But it did not significantly influence by the Sulphur and Zinc. Similar results were reported by Acharya *et al.* (2015) [2]

Number of scales per bulb recorded between 6.01 to 7.15 it is found maximum in treatment T_{10} [10kg(zinc EDTA 12%)ha^{-1}] (7.15) which is at par with T_5 (75kgSha^{-1}) (7.14), T_4 (56.25kgSha^{-1}) (7.13), T_9 [7.5kg (zinc EDTA12%)ha^{-1}] (7.12), T_3 (37.5kgSha^{-1}) (6.98), T_8 [5kg(zinc EDTA 12%)ha^{-1}] (6.94), T2 (18.75 kgSha^{-1}) (6.67), T_7 [2.5kg(zinc EDTA 12%)ha^{-1}] (6.64), and lowest in control plot T_1 (6.01). Similar results were reported by Rashid *et al.* (2010) [10].

The maximum girth of bulb was found with the treatment T_{10} [10 kg (zinc EDTA 12%) ha^{-1}] (10.96g) and minimum was with the treatment T_3 [10 kg (zinc EDTA 12%) ha^{-1}] (8.46g). But it did not significantly influence by the Sulphur and Zinc. Similar results were reported by Acharya *et al.*, (2015) [2].

Dry matter of tops recorded between 9.11q to 14.00q at harvesting time. It is found highly significant and it is at par with T_5 (75kgSha^{-1}) (14.00q), T_{10} [10kg(zinc EDTA 12%)ha^{-1}] (13.90q), T_4 (56.25kgSha^{-1}) (13.86q), T_9 [7.5kg (zinc EDTA12%)ha^{-1}] (13.81q), T_3 (37.5kgSha^{-1}) (13.59q), T_8 [5 kg (zinc EDTA 12%) ha^{-1}] (13.40q), T_7 [2.5 kg (zinc EDTA 12%)ha^{-1}] (12.13q), T_2 (18.75 kgSha^{-1}) (11.83q), and lowest in control plot T_1 (9.11q). Similar results were reported by Khodadadi *et al.* (2012) [6].

Fresh weight of bulb recorded between 60.2g to 0.96.68g. It is found highly significant and it is at par with T_5 (75kgSha^{-1}) (96.68g), T_{10} [Zn4 10kg (zinc EDTA 12%) ha^{-1}] (96.00g), and lowest in control plot T_1 (60.2g). Similar results were reported by Acharya *et al.* (2015) [2], Mishu *et al.* (2013) [7].

Bulb yield kg per plot recorded between 9.7 kg to 13.66 kg. It is found highly significant and it is at followed by T_5 (75kgSha^{-1}) (13.66kg), T_{10} [10kg (zinc EDTA 12%) ha^{-1}] (13kg), T_9 [7.5kg (zinc EDTA 12%) ha^{-1}] (11.76kg), T_3 (37.5kgSha^{-1}) (11.6kg), T_4 (56.25kgSha^{-1}) (11.56kg), and lowest in control plot T_1 (9.7kg).

At harvest the bulb yield (q/ha^{-1}) recorded between 255.72 to 361.54q. It is found highly significant and it is followed by T_5 (75kgSha^{-1}) (361.54q), T_{10} [10kg (zinc EDTA 12%) ha^{-1}] (343.91q), T_9 Zn3 [7.5kg (zinc EDTA12%) ha^{-1}] (311.28q), T_4 (56.25kgSha^{-1}) (306.87q.), T3 (37.5kgSha^{-1}) (305.99q), and lowest in control plot T_6 (255.72q). Similar results were reported by Abedin *et al.* (2012) [1], Acharya *et al.* (2015) [2], Dake *et al.* (2011) [3], Jaggi (2005) [5], Mousavi *et al.* (2007) [8], Poornima *et al.* (2016) [9], Rashid (2010) [10], Singh and Tiwari (1995) [12], Yadav and Gumber (2008) [13].

Economic analysis

Present study revealed that the highest cost of cultivation was recorded under T_5 (75kgSha^{-1}). The highest gross income 206081.60 ₹ /ha had realized in treatment T_5 (75 kg Sha^{-1}). Highest net return was recorded in treatment T_5 [7.5 kg (zinc EDTA 12%) ha^{-1}] 78366.78 ₹ ha^{-1} followed by T_{10} [10kg (zinc EDTA 12%) ha^{-1}] which has net return 72776.38 ₹ ha^{-1}. The highest cost: benefit ratio was found with T_5 (75 kg Sha^{-1}) followed by T_{10} [10 kg (zinc EDTA 12%) ha^{-1}], T_9 [7.5 kg (zinc EDTA 12%) ha^{-1}], T_3 S2 37.50 kg Sha^{-1}, T_8 [Zn2 5kg (zinc EDTA 12%) ha^{-1}], T_4 (S3 56.25 kg Sha^{-1}), T_2 (S3 18.75 kg Sha-1), and T_7 [2.5 kg (zinc EDTA 12%) ha^{-1}]. The lowest cost: benefit ratio was found with T_1 (control plot) and T_6 (control plot).

Looking to the economics common expenditure on all treatments were:

Table 3: Effect of different treatments of Neck thickness of bulbs, equatorial diameter, polar diameter, girth of bulb, no. of scales per bulb, and dry matters of tops at different stages

Treats.	Neck thickness of bulbs	Equatorial diameter	Polar diameter	Girth of bulb	Number of scales per bulb	Dry matter of tops
T_1	0.48	5.30	4.23	9.7	6.01	9.11
T_2	0.56	5.31	4.29	9.8	6.62	11.83
T_3	0.60	5.80	4.85	8.46	6.98	13.59
T_4	0.68	6.04	4.90	8.58	7.13	13.86
T_5	0.72	6.34	5.26	10.6	7.14	14.00
T_6	0.62	5.27	4.86	9.72	6.03	9.18
T_7	0.75	5.99	4.96	9.92	6.64	12.13
T_8	0.76	6.02	5.27	10.54	6.94	13.40
T_9	0.81	6.31	5.38	10.76	7.12	13.81
T_{10}	0.84	6.33	5.48	10.96	7.15	13.90
S.Em±	0.076	0.66	0.45	0.91	0.27	0.91
C.D. 5% level	0.22	NS	NS	NS	0.82	2.71

Table 4: Effect of different treatments of fresh weight of bulb, bulb yield (kg/plot) and bulb yield (q/ha) at different stages

Treats.	Fresh weight of bulb(g)	Bulb yield (kg/plot)	Bulb yield (qha^{-1})
T_1	60.20	9.70	256.61
T_2	72.48	10.63	281.30
T_3	82.08	11.60	306.87
T_4	89.02	11.56	305.99
T_5	96.68	13.66	361.54
T_6	61.30	9.66	255.72
T_7	71.47	10.40	275.12
T_8	72.48	11.33	299.82
T_9	82.08	11.76	311.28
T_{10}	96	13.00	343.91
S.Em±	0.46	0.13	3.51
C.D. 5% level	1.36	0.39	10.45

Table 5: Economics of different treatment

Treatments	Bulb yield (q^{-1} ha^{-1})	Gross income (₹ha^{-1})	Experiment (₹ha^{-1})	Net income (₹ha^{-1})	B:C Ratio
T_1	256.61	146267.7	113652.32	32615.35	1:1.28
T_2	281.30	160341.00	117167.94	43173.06	1:1.36
T_3	306.87	174917.80	120683.94	54233.86	1:1.44
T_4	305.99	174414.30	124198.82	50215.48	1:1.40
T_5	361.54	206081.60	127714.82	78366.78	1:1.61
T_6	255.72	145764.20	113652.32	32111.88	1:1.28
T_7	275.12	156822.20	116052.32	40769.88	1:1.35
T_8	299.82	170897.40	118452.32	52445.08	1:1.44
T_9	311.28	177429.60	120852.32	56577.28	1:1.46
T_{10}	343.91	196028.70	123252.32	72776.38	1:1.59

Common expenditure: Include expenditure on operations performed equally in all treatments.

Extra expenditure: Include expenditure of treatments

1. Control plot [₹ 0 ha^{-1}]
2. S1 18.75 kg Sha-1 [₹ 3515ha^{-1}]
3. S2 37.50 kg Sha-1 [₹ 7031.25ha-1]
4. S3 56.25 kg Sha-1 [₹ 10546.50 ha^{-1}]
5. S4 75 kg Sha-1 [₹14062.5ha^{-1}]
6. Control plot [₹ ha^{-1}]
7. Zn1 2.5 kg (zinc EDTA 12%) ha-1 [₹ 2400ha^{-1}]
8. Zn2 5 kg (zinc EDTA 12%) ha-1 [₹ 4800ha^{-1}]
9. Zn3 7.5 kg (zinc EDTA 12%) ha-1 [₹ 7200ha^{-1}]
10. Zn5 10 kg (zinc EDTA 12%) ha-1 [₹ 9600ha^{-1}]

Gross income: The prevailing market price of onion bulb was considered @ 570 ₹q^{-1}

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