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Studies on influence of sulphur, zinc combination on growth, yield of onion var. Arka Kalyan

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Abstract
A field trial on influence of sulphur and zinc combination on growth, yield and quality of onion var. Arka Kalyan was carried out during *Kharif* 2015 and *Kharif* 2016 at Kittur Rani Channamma College of Horticulture, Arabhavi, Karnataka. The experiment was laid out as two factorial RBD involving four levels of sulphur (0, 20, 30 and 40 kg sulphur/ha) and zinc (0, 5, 10 and 10 kg zinc/ha) comprising 16 treatment combinations of sulphur and zinc including control (S_0Z_0). Sulphur and Zinc fertilizers were applied one month after the transplanting as per the treatment combinations. The maximum plant height (52.03, 52.59 and 52.31 cm), number of leaves (9.37, 10.72 and 10.04), leaf area (68.72, 66.69 and 67.71 cm^2), leaf area index (0.46, 0.44 and 0.45), neck thickness (9.54, 10.59 and 10.06 mm) at 90 days after transplanting (DAT) and also higher bulb yield (21.70, 21.90 and 21.80 t ha^{-1}) was recorded by S_3 (RDF+40 kg S/ha). Among the zinc levels, Z_3 (RDF+15 kg Zn/ha) recorded maximum plant height (48.66, 50.10 and 49.38 cm), number of leaves (7.83, 9.57 and 8.70), leaf area (56.81, 57.29 and 57.05 cm^2), leaf area index (0.38, 0.38 and 0.38) and higher bulb yield (21.03, 21.30 and 21.17 t ha^{-1}). Among the interaction effect S_3Z_3 (RDF + 40 kg S/ha + 15 kg Zn/ha) recorded significantly maximum leaf area (75.41, 73.77 and 74.59 cm^2) and leaf area index (0.50, 0.49 and 0.50) and also registered significantly maximum bulb yield (23.22, 24.51 and 23.87 t ha^{-1}) in 2015, 2016 and pooled data respectively.

Keywords: Onion, sulphur levels, zinc levels, interaction effect, bulb yield

Introduction
Onion (*Allium cepa* L.) belonging to the family Alliaceae is widely used as vegetable and spice. The genus including the various edible onions, garlics, chives and leeks, has played a pivotal role in cooking worldwide, as the various parts of the plants, either raw or cooked in many ways, produce a large variety of flavours and textures. It has been cultivated for 5000 years or more and does not exist as wild species (Brewster, 1994) [8] of the 15 vegetable and spice crops listed by FAO. The leading onion producing countries are China, India, USA, Iran and Russian Federation. Within India, the leading onion producing states are Maharashtra, Madhya Pradesh and Karnataka. In India it occupy an area of 12.70 lakh hectare producing 215.64 lakh MT and average productivity is 17.00 tonnes per hectare. In Karnataka, it is having an area of 1.20 lakh hectares with an annual production of 32.54 lakh tonnes and the average productivity is 14.16 tonnes per hectare (Anon., 2017) [5]. Continuous use of sulphur free fertilizers like urea and DAP causes its deficiency in onion. In nitrogen deficient plants, lower and upper all leaves shows symptoms whereas in sulphur deficient plants it appear on the new leaves only (Rajasekar *et al.*, 2017) [25].

Micronutrients play an active role in the plant metabolic process from cell wall development to respiration, photosynthesis, chlorophyll formation, enzymes activity, nitrogen fixation *etc*. Zinc is the most important micro-nutrient and is essential for cell division, carbohydrate metabolism and water relation in plant growth (Brady, 1990) [7]. Application of micronutrients to soil deficient in them has shown remarkable increase in yield of several crops. Although zinc is required in trace amounts for plants but, if it is not available in required amount, the deficiency of zinc creates physiological imbalances and affects enzyme activities and other metabolic processes (Baybordi, 2006). Zinc deficiency is reported to be widespread in Indian soils and it is considered that a hidden hunger in crops for this element is responsible for sub-optimum productivity on extensive areas in the country (Kanwar and Randhawa, 1974) [14]. Zinc deficiency in onions shows up as stunting with marked twisting and bending of yellow-striped tops (Alloway, 2008) [4].

Research information on effect of application of sulphur and zinc or their combination in onion production in Karnataka region is limited. Hence, keeping in view the above facts, the present investigation was undertaken with the following objectives:

1. To study the influence of sulphur on growth, yield and quality of onion.
2. To study the influence of zinc on growth, yield and quality of onion.

Material and Methods

The field experiment was carried out at Kittur Rani Channamma College of Horticulture, Arabhavi (Northern dry zone of Karnataka state at 16°15' N latitude, 74°45' E longitude at an altitude of 612.03 meters above the mean sea level), Karnataka during *Kharif* 2015 and *Kharif* 2016. The details of the materials used and the techniques adopted during the investigations are presented here under.

The experiment was laid out in a two factorial randomized block design with four levels of sulphur (0, 20, 30 and 40 kg S/ha) and four levels of zinc (0, 5, 10 and 10 kg Zn/ha) along with recommended dose of fertilizers. Sulphur and Zinc fertilizers were applied one month after the transplanting as per the treatment combinations.

A spacing of 15 cm between rows and 10 cm between the plants (ridge and furrow method) was followed. FYM (30 t/ha) was applied 15 days before transplanting and the recommended dose of fertilizers for onion *i.e.*, 125:75:125 kg half dose of N, full dose of P_2O_5 and K_2O per ha was applied at the time of transplanting (As per package of practice, UHS, Bagalkot). The remaining N was applied as top dressing at 45 days after transplanting. Further, the crop was grown with necessary cultural operations as per the recommendations of the university.

Cosavet Fertis-WG (90% sulphur) was used as a sulphur source manufactured by sulphur mills Ltd., Mumbai (MH), India. Power Feed-High Zinc (10% Zinc) was used as zinc source manufactured by Sindhuri Agrotech, Guntur (AP), India. Sulphur and Zinc were applied one month after the transplanting as per the treatment combinations. Five representative plants were selected randomly from each plot and the average from these five plants was worked out for the statistical computation. The data recorded for various observations were subjected to statistical analysis using the Fischer's method of analysis of variance as described by Panse and Sukhatme, (1985) [22].

Results and Discussion

Growth parameters

The data pertaining to the different growth parameters such as plant height, number of leaves, leaf length, leaf area and neck thickness at 90 days after transplanting as influenced by sulphur and zinc levels and their interactions during 2015, 2016 and pooled data are presented in Table 1a and 1b.

The dose of sulphur @ 40 kg/ha was found to be superior which registered significantly higher growth attributes such as plant height (52.03, 52.59 and 52.31 cm), number of leaves per plant (9.37, 10.72 and 10.04), leaf area (68.72, 66.69 and 67.71 cm^2), leaf area index (0.46, 0.44 and 0.45) and neck thickness (9.54, 10.59 and 10.06 mm) during 2015, 2016 and in pooled data compared to other treatments. These results may be related to the benefits of adequate sulphur supplies to the plants, because either low or excessive doses are detrimental to growth and development crops. The improvement in growth characters with the application of sulphur might be due to its role in the synthesis of chlorophyll (Nagaich *et.al*, 1999) [21]. Sulphur is an essential plant nutrient, its role in balanced fertilization and consequently in crop production is being realized in recent times. It performs many physiological functions like synthesis of sulphur containing amino acids. Overall increase in growth attributes of crop might be due to higher availability of sulphur in the rhizosphere system of the plants which might have resulted in increased uptake of nutrients and were used in photosynthesis. Several researchers also noticed significant response of onion to sulphur application for these traits [Jana and Kabir (1990), Nagaich *et al.* (1999)] [12, 21].

Among the zinc levels, significantly higher growth attributes such as number of leaves per plant (8.70), leaf area (57.05 cm^2), leaf area index (0.38) and neck thickness (9.18 mm) were recorded by the treatment Z_3 (RDF + 15 kg Zn/ha) in pooled data respectively compared to other treatments. The interaction effects between sulphur and zinc on growth parameters were found to be non-significant except for leaf area and leaf area index. Increase in growth attributes might be due to the fact that besides the role of zinc in chlorophyll formation, it also influenced cell division, meristematic activity of tissues, and expansion of cell and formation of cell wall (Chhipa, 2005) [10]. Results are in accordance with findings of Mishra *et al.* (1990) [18], who noted that foliar application of $ZnSO_4$ (0.5%) significantly increased plant height and other growth parameter of onion than control. The similar results were also recorded by many scientists in onion (Alam *et al.*, 2010 and Abd El-Samad *et al.*, 2011) [3, 1]. They reported that growth parameters of onion plant were positively affected by application of micronutrients.

Yield attributes

Among the sulphur levels, significantly higher bulb weight (70.71, 74.76 and 72.74 g), bulb yield/ plot (19.53, 19.71 and 19.62 kg) and bulb yield/ ha (21.70, 21.90 and 21.80 t) was recorded by the treatment S_3 (RDF + 40 kg S/ha) during 2015, 2016 and in pooled data respectively (Table 2). This might be ascribed to adequate supply of sulphur that resulted in higher production of photosynthates and their translocation to sink, which ultimately increased the fresh yield of onion. Increasing sulphur availability has been associated with increasing bulb weight (Lancaster *et al.*, 2001) [16]. Similar report has been reported by Josephine *et al.* (2006) [13] and Mozumder *et al.* (2007) [19].

Application of RDF along with sulphur and zinc increased the uptake of N, P, K, S and Zn there by higher production of metabolites and meristematic activity. Besides, it could be attributed to improvement in nutritional environment in crop root zone and ultimately resulted in better vegetative growth and finally the higher bulb yield. The soil low in sulphur was unable to supply the nutrient significantly for optimum growth and yield of crop. The increase in bulb yield was mainly due to enhanced rate of photosynthates and carbohydrate metabolism as influenced by sulphur application (Pradhan *et al.*, 2015) [23]. Kumar and Singh (2004) [15] reported enhanced bulb yield due to sulphur application. Again these results might be attributed to the favourable effect of sulphur on reducing soil pH, increasing soil particles, thereby improving soil structure and increasing the availability of certain plant nutrients in soil. Another possibility could be due to either the fact that higher sulphur is required for onion than other crops for the synthesis of coenzyme and amino acid for protein elaboration and for the formation of certain disulphide linkages that have been

associated with structural characteristics of plant protoplasm (Marschner, 1995) [17]. Similar results in increase in total bulb yield of onion with sulphur fertilization were also reported by (Hariyappa, 2003; Channagoudra *et al*., 2009; Pradhan *et al.*, 2015) [11, 9, 23].

With respect to zinc levels, significantly higher bulb weight (68.90 g), bulb yield/ plot (19.05 kg) and bulb yield/ hectare (21.017 t) was recorded by the treatment Z_3 (RDF + 15 kg Zn/ha) in pooled data compared to other treatments (Table 2). The interaction effects between sulphur and zinc on bulb yield were found to be significant for bulb yield per plot and bulb yield per hectare and the combination treatment S_3Z_3 recorded significantly higher bulb yield parameters compared to other treatments. This might be due to the main function of zinc in plant as a metal activator of several enzymes like dehydrogenase, proteinase and peptidases (Prasad and Kumar, 2010) [24]. The beneficial effect of zinc on the yield parameters may be attributed due to the fact that soil application of zinc resulted in increased supply of the available zinc to the plants which led to proper growth and development. The essential role of zinc has been established as a component of several enzymes which are concerned with carbohydrate and nitrogen metabolism, in addition to its involvement directly or indirectly in regulating the various physiological processes (Marschner, 1995) [17]. The findings were in conformity with the findings of Thakare *et al.* (2007) [26] and Ballabh *et al.*, (2013).

In general, the yield response of onion to sulphur (40 kg/ha) and zinc (15 kg/ha) along with the recommended dose of fertilizers (NPK) were relatively higher over the control. In this regard, the result may be due to the role of nitrogen in chlorophyll, enzymes and proteins synthesis and phosphorus on root growth development, phosphoproteins and phospho-lipids formation. The moderate dose of sulphur (40 kg/ha) was found to increase the diameter and weight of bulbs significantly (Ahmed *et al.,* 1988) [2]. Mukesh *et al.* (1997) [20] reported that the high fresh onion yield was achieved on plots treated with zinc at the rate of 10 kg/ha.

Table 1a: Growth parameters in onion as influenced by sulphur and zinc (90 days after transplanting)

Treatments	90 DAT								
	Plant height (cm)			Number of leaves per plant			Leaf area (cm^2)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
S_0 (RDF)	41.94	45.53	43.74	5.62	7.43	6.53	35.24	42.19	38.71
S_1 (RDF+20 kg/ha)	45.93	48.10	47.01	6.80	8.73	7.77	43.42	50.46	46.94
S_2 (RDF+30 kg/ha)	48.95	50.91	49.93	7.75	9.70	8.73	58.86	59.01	58.94
S_3 (RDF+40 kg/ha)	52.03	52.59	52.31	9.37	10.72	10.04	68.72	66.69	67.71
SEm±	0.21	0.16	0.10	0.10	0.09	0.07	1.14	2.02	1.31
CD at 5%	0.62	0.46	0.29	0.28	0.26	0.19	3.29	5.83	3.79
Z_0 (RDF)	45.67	48.25	46.96	6.90	8.72	7.81	46.32	49.42	47.87
Z_1 (RDF+5 kg/ha)	46.68	49.05	47.87	7.27	9.03	8.15	51.02	55.68	53.35
Z_2 (RDF+10 kg/ha)	47.84	49.73	48.79	7.53	9.27	8.40	52.10	55.95	54.03
Z_3 (RDF+15 kg/ha)	48.66	50.10	49.38	7.83	9.57	8.70	56.81	57.29	57.05
SEm±	0.25	0.18	0.12	0.11	0.10	0.08	1.31	2.33	2.62
CD at 5%	0.62	0.46	NS	0.28	0.26	0.19	3.29	5.83	7.57
S_0Z_0	39.60	43.95	41.77	5.53	6.73	6.13	34.53	44.48	39.51
S_0Z_1	41.18	45.46	43.32	5.33	7.40	6.37	34.53	41.06	37.79
S_0Z_2	43.09	46.25	44.67	5.67	7.60	6.63	35.76	40.50	38.13
S_0Z_3	43.88	46.47	45.18	5.93	8.00	6.97	36.15	42.70	39.42
S_1Z_0	44.25	46.83	45.54	6.27	8.33	7.30	40.21	45.34	42.78
S_1Z_1	45.52	47.44	46.48	6.87	8.67	7.77	45.35	54.31	49.83
S_1Z_2	46.51	48.8	47.66	6.93	8.87	7.90	41.88	53.62	47.75
S_1Z_3	47.42	49.34	48.38	7.13	9.07	8.10	46.25	48.57	47.41
S_2Z_0	48.08	50.21	49.15	7.20	9.47	8.33	44.84	42.69	43.77
S_2Z_1	48.27	51.00	49.64	7.67	9.53	8.60	58.86	62.86	60.86
S_2Z_2	49.36	51.03	50.19	7.93	9.80	8.87	62.31	66.38	64.35
S_2Z_3	50.09	51.41	50.75	8.20	10.00	9.10	69.43	64.12	66.77
S_3Z_0	50.74	52.01	51.38	8.60	10.33	9.47	65.69	65.16	65.43
S_3Z_1	51.74	52.30	52.02	9.20	10.53	9.87	65.33	64.51	64.92
S_3Z_2	52.41	52.84	52.63	9.60	10.80	10.20	68.45	63.32	65.88
S_3Z_3	53.23	53.19	53.21	10.07	11.20	10.63	75.41	73.77	74.59
SEm±	0.43	0.32	0.20	0.19	0.18	0.13	2.28	4.03	2.62
CD at 5%	NS	NS	0.58	NS	NS	NS	6.58	11.65	7.57
CV (%)	1.57	1.11	0.72	4.52	3.36	2.79	7.65	12.8	8.55

RDF- 125:75:125 kg NPK/ha+30 t/ha FYM, NS- Non significant

Table 1b: Growth parameters in onion as influenced by sulphur and zinc (90 days after transplanting)

Treatments	90 DAT					
	Leaf area index			Neck thickness		
	2015	2016	Pooled	2015	2016	Pooled
S_0 (RDF)	0.23	0.28	0.26	7.76	8.03	7.89
S_1 (RDF+20 kg/ha)	0.29	0.34	0.31	8.15	8.77	8.46
S_2 (RDF+30 kg/ha)	0.39	0.39	0.39	8.61	9.43	9.02
S_3 (RDF+40 kg/ha)	0.46	0.44	0.45	9.54	10.59	10.06
SEm±	0.01	0.01	0.01	0.10	0.09	0.06
CD at 5%	0.02	0.04	0.03	0.30	0.25	0.18

Z_0 (RDF)	0.31	0.33	0.32	8.23	8.80	8.52
Z_1 (RDF+5 kg/ha)	0.34	0.37	0.36	8.43	9.08	8.75
Z_2 (RDF+10 kg/ha)	0.35	0.37	0.36	8.61	9.38	8.99
Z_3 (RDF+15 kg/ha)	0.38	0.38	0.38	8.77	9.58	9.18
SEm±	0.01	0.02	0.01	0.12	0.10	0.07
CD at 5%	0.02	0.04	0.03	0.30	0.25	0.18
S_0Z_0	0.23	0.30	0.26	7.52	7.64	7.58
S_0Z_1	0.23	0.27	0.25	7.70	7.88	7.79
S_0Z_2	0.24	0.27	0.25	7.84	8.21	8.03
S_0Z_3	0.24	0.28	0.26	7.97	8.39	8.18
S_1Z_0	0.27	0.30	0.29	8.04	8.48	8.26
S_1Z_1	0.30	0.36	0.33	8.09	8.72	8.41
S_1Z_2	0.28	0.36	0.32	8.18	8.82	8.50
S_1Z_3	0.31	0.32	0.32	8.27	9.05	8.66
S_2Z_0	0.30	0.28	0.29	8.32	9.10	8.71
S_2Z_1	0.39	0.42	0.41	8.52	9.28	8.90
S_2Z_2	0.42	0.44	0.43	8.73	9.61	9.17
S_2Z_3	0.46	0.43	0.45	8.87	9.74	9.31
S_3Z_0	0.44	0.43	0.44	9.06	9.96	9.51
S_3Z_1	0.44	0.43	0.43	9.40	10.42	9.91
S_3Z_2	0.46	0.42	0.44	9.70	10.86	10.28
S_3Z_3	0.50	0.49	0.50	9.99	11.13	10.56
SEm±	0.02	0.01	0.02	0.21	0.18	0.13
CD at 5%	0.02	0.04	0.05	NS	NS	NS
CV (%)	7.65	12.8	8.55	4.23	3.31	2.49

RDF- 125:75:125 kg NPK/ha+30 t/ha FYM NS- Non significant

Table 2: Bulb yield parameters in onion as influenced by sulphur and zinc

Treatments	Bulb weight (g)			Bulb yield (kg/plot)			Bulb yield (t/ha)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
S_0 (RDF)	58.63	69.65	64.14	17.22	17.73	17.48	19.14	19.70	19.42
S_1 (RDF+20 kg/ha)	61.62	70.77	66.19	18.22	18.11	18.16	20.24	20.12	20.18
S_2 (RDF+30 kg/ha)	64.55	73.00	68.77	18.74	18.36	18.55	20.82	20.40	20.61
S_3 (RDF+40 kg/ha)	70.71	74.76	72.74	19.53	19.71	19.62	21.70	21.90	21.80
SEm±	0.50	0.49	0.34	0.12	0.15	0.10	0.13	0.17	0.11
CD at 5%	1.45	1.41	0.99	0.34	0.45	0.28	0.37	0.50	0.32
Z_0 (RDF)	62.59	71.40	66.99	18.02	17.73	18.06	20.03	20.11	20.07
Z_1 (RDF+5 kg/ha)	63.23	72.01	67.62	18.28	18.11	18.25	20.31	20.26	20.28
Z_2 (RDF+10 kg/ha)	64.36	72.29	68.33	18.49	18.36	18.45	20.55	20.45	20.50
Z_3 (RDF+15 kg/ha)	65.33	72.48	68.90	18.93	19.71	19.05	21.03	21.30	21.17
SEm±	0.58	0.57	0.40	0.13	0.18	0.11	0.15	0.20	0.13
CD at 5%	1.45	NS	1.98	0.34	0.45	0.28	0.37	0.50	0.32
S_0Z_0	57.71	68.23	62.97	16.72	17.54	17.13	18.58	19.49	19.03
S_0Z_1	58.06	69.77	63.91	17.17	17.66	17.42	19.07	19.63	19.35
S_0Z_2	59.01	70.27	64.64	17.33	17.79	17.56	19.26	19.77	19.51
S_0Z_3	59.75	70.33	65.04	17.67	17.94	17.80	19.63	19.93	19.78
S_1Z_0	60.45	70.60	65.52	18.00	17.98	17.99	20.00	19.98	19.99
S_1Z_1	60.99	70.87	65.93	18.10	18.07	18.09	20.11	20.08	20.10
S_1Z_2	62.07	70.83	66.45	18.23	18.13	18.18	20.26	20.14	20.20
S_1Z_3	62.98	70.77	66.87	18.53	18.25	18.39	20.59	20.28	20.44
S_2Z_0	63.31	72.73	68.02	18.70	18.27	18.49	20.78	20.30	20.54
S_2Z_1	64.05	72.93	68.49	18.77	18.33	18.55	20.85	20.37	20.61
S_2Z_2	64.86	73.07	68.97	18.90	18.39	18.64	21.00	20.43	20.71
S_2Z_3	65.97	73.27	69.62	18.60	18.44	18.52	20.67	20.49	20.58
S_3Z_0	68.88	74.03	71.46	18.67	18.60	18.64	20.74	20.67	20.71
S_3Z_1	69.82	74.47	72.14	19.07	18.85	18.96	21.19	20.95	21.07
S_3Z_2	71.51	75.00	73.26	19.50	19.31	19.41	21.67	21.46	21.56
S_3Z_3	72.64	75.53	74.09	20.90	22.06	21.48	23.22	24.51	23.87
SEm±	1.00	0.98	0.68	0.23	0.31	0.20	0.26	0.34	0.22
CD at 5%	NS	NS	NS	0.67	0.89	0.57	0.75	0.99	0.63
CV (%)	2.72	2.36	1.74	2.18	2.90	1.85	2.18	2.90	1.85

RDF- 125:75:125 kg NPK/ha+30 t/ha FYM NS- Non significant

Conclusion

Among the sulphur levels, S_3 (40 kg S/ha) along with RDF (125:75:125 kg NPK/ha + 30 t/ha FYM) performed better with respect to growth and yield attributes in onion. Among zinc levels, Z_3 (15 kg Zn/ha) along with RDF (125:75:125 kg NPK/ha + 30 t/ha FYM) found to be superior for getting higher growth and yield parameters in onion under irrigated ecosystem of Northern dry zone of Karnataka.

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