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Response of different levels of sulphur, zinc and boron on yield and quality of onion in Vertisols of north eastern Karnataka

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Abstract
An investigation was undertaken with fifty mustard genotypes to study the correlation and path A field experiment was conducted consecutively on 2020 and 2021 at Gotur village of Kalagi taluka in Kalaburagi district of North Eastern Dry Zone (Zone-2) of Karnataka to study the effect of sulphur, zinc and boron on yield and quality of onion in *vertisol*. The experiment consisted of ten treatments which were laid out in randomized complete block design with three replications. The pooled results of two years revealed that, application of Sulphur @ 30 kg ha^{-1} + Zinc @ 4 kg ha^{-1} + Boron @ 1.5 kg ha^{-1} along with recommended dose of fertilizers (T_{10}) significantly recorded highest plant height (33.71, 54.53, 63.39 cm at 30, 60, 90 DAT), number of leaves per plant (7.66, 9.64, 10.19 at 30, 60, 90 DAT), leaf length (24.88, 36.65, 42.92 cm at 30, 60, 90 DAT), bulb length (6.21 cm), bulb diameter (6.61 cm), weight of bulb (84.25 g), bulb yield per plot (33.92 kg), bulb yield per hectare (30.19 t ha^{-1}), total soluble solids (15.38 ^{o}Brix), ascorbic acid (13.37 mg $100g^{-1}$) and protein content of bulb (15.18%) and it was found on par with application of Sulphur @ 20 kg ha^{-1} + Zinc @ 2 kg ha^{-1} + Boron @ 1 kg ha^{-1} along with recommended dose of fertilizers (T_9). The results clearly indicated that application of Sulphur @ 30 kg ha^{-1} + Zinc @ 4 kg ha^{-1} + Boron @ 1.5 kg ha^{-1} along with recommended dose of fertilizers (T_{10}) significantly improved growth, yield and quality parameters of onion compared to other treatments and also found highest gross return (₹483040), net return (₹395626) and B:C ratio (5.53) of onion.

Keywords: sulphur, zinc, boron, onion, growth, yield and quality

Introduction
Onion requires sufficient amount of plant nutrients and responds very well to the added nutrients (Alam *et al*. 2010) [2]. Sulphur is recognized as the fourth major plant nutrient after nitrogen, phosphorus and potassium in crops. It is a component of vitamin A and activates certain enzyme systems in plants. Sulphur deficiency in Indian soil adversely affects crop production besides recommended dose of NPK fertilizers application (Surendra Singh, 2008) [19]. Sulphur not only influence the taste, pungency and medicinal properties of onion but also impart resistance against pests and diseases. Sulphur is also required for the synthesis of three important amino acids such as cystine (27% S), cysteine (26% S) and methionine (21% S) (Randle and Bussard, 1993) [14]. Continuous removal of Sulphur from soils through plant uptake has led to widespread S deficiency all over the world (Zaman *et al*., 2011) [22]. Zinc plays an important role in various enzymatic and physiological activities of the plant body. Zinc is taken up by plants as Zn^{+2}. The functional role of zinc includes auxin metabolism, influence on the activity of carbonic anhydrase, dehydrogenase enzymes, cytochrome synthesis and stabilization of ribosomal fractions (Tisdale *et al*., 1984) [20]. Zinc also plays a significant role in chlorophyll formation. Boron is a micronutrient it performs wide range of functions in onion plant. It helps in movement of nutrient elements within the plant, it is very sensitive element and plants differ widely in their requirements but the ranges of deficiency and toxicity are narrow. It maintains balance between sugar and starch in plant body (Laxmi *et al*. 2019) [11]. Information on effect of combined application of S, Zn and B on yield, quality and uptake of nutrients in onion is rather limited. Therefore, the present study was initialized to study the effect of S, Zn and B application on yield, quality and uptake of nutrients by onion in North Eastern Dry Zone (Zone-2) of Karnataka.

Material and Methods
The field experiment was conducted on 2020 and 2021 at Gotur village of Kalagi taluka in Kalaburagi district, which is situated at 17º 20' N latitude and 77º 09' E longitude and at an altitude of 436.23 meters above mean sea level and is located in North Eastern Dry Zone (Zone-2) of Karnataka.

The experiment was laid out in randomized complete block design (RCBD) with three replications and ten treatments *viz.*, T_1 (control), T_2 (RDF), T_3 (RDF + sulphur @ 20 kg ha^{-1}), T_4 (RDF + sulphur @ 30 kg ha^{-1}), T_5 (RDF + zinc @ 2 kg ha^{-1}), T_6 (RDF + zinc @ 4 kg ha^{-1}), T_7 (RDF + boron @ 1 kg ha^{-1}), T_8 (RDF + boron @ 1.5 kg ha^{-1}), T_9 (RDF + sulphur @ 20 kg ha^{-1} + zinc @ 2 kg ha^{-1} + boron @ 1 kg ha^{-1}) and T_{10} (RDF + sulphur @ 30 kg ha^{-1} + zinc @ 4 kg ha^{-1} + boron @ 1.5 kg ha^{-1}). Onion seedlings of 30 days old were transplanted with spacing of 15x10 cm. Fertilizers were applied to soil on the day of transplanting as per the treatment details. Sulphur, zinc and boron were supplied as per the treatment requirements through bentonite sulphur, Zinc sulphate and Borax fertilizers respectively. All the recommended agronomic practices and crop husbandry were followed to raise a good crop. Five plants were selected randomly from each net plot to record the observation namely, plant height, number of leaves per plant, leaf length, bulb length, bulb diameter, weight of bulb per plant, bulb yield per plot, bulb yield per hectare, total soluble solids (TSS), ascorbic acid and protein content of bulb. The statistical analysis was done as per the procedure given by Gomez and Gomez (1984) [6].

Results and Discussions

Growth parameters

The pooled data of 2020 and 2021 on growth parameters as affected by sulphur, zinc and boron levels at various growth stages (30, 60 and 90 DAT) of onion are presented in table 1 table 2 and table 3.

Growth parameters of onion were significantly influenced by sulphur, zinc and boron levels at all growth stages of crop in both the years (2020 and 2021). At 30 DAT, the application of 30 kg S ha^{-1}, 4 kg Zn ha^{-1} and 1.5 kg B ha^{-1} (T_{10}) along with recommended dose of fertilizers recorded significantly higher plant height (table 1) (33.71 cm), number of leaves per plant (table 2) (7.66) and leaf length (table 3) (24.88 cm) compared to all other treatments. However, it was on par with 20 kg S ha^{-1}, 2 kg Zn ha^{-1} and 1 kg B ha^{-1} (T9). Significantly lower plant height (table 1) (22.72 cm), number of leaves per plant (table 2) (5.09) and leaf length (table 3) (19.38 cm) were recorded in control (T_1). Similar trend was noticed at 60 and 90 DAT. Application of sulphur, zinc and boron through soil or in combination had a beneficial effect on growth of onion. This may be due to added sulphur enhanced the synthesis of chlorophyll content in the leaves (Hore *et al.*, 2014) [7]. Similarly, zinc and boron play an essential role in plant growth through the biosynthesis of endogenous hormones which is responsible for promotion of plant growth and role in cell division, meristematic activity of plant tissue and expansions of cells as explained by Khatemenla *et al.* (2018) [9]. The results are similar to findings of Bhatt *et al.* (2004) [4].

Yield parameters

The pooled data of 2020 and 2021 on yield parameters as affected by sulphur, zinc and boron levels at various growth stages (30, 60 and 90 DAT) of onion are presented in table 4.

Table 1: Effect of different levels of sulphur, zinc and boron on plant height (cm) of onion.

Treatments		30 DAT			60 DAT			90 DAT		
		2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1	Control (C)	23.01	22.43	22.72	35.98	35.95	35.97	49.47	47.69	48.58
T_2	RDF	26.97	24.23	25.60	38.72	38.61	38.67	53.25	49.7	51.48
T_3	RDF + sulphur @ 20 kg ha^{-1}	27.08	24.48	25.78	44.51	42.26	42.39	57.59	54.52	56.06
T_4	RDF + sulphur @ 30 kg ha^{-1}	28.82	27.53	28.18	47.17	46.82	47.00	58.58	56.24	57.41
T_5	RDF + zinc @ 2 kg ha^{-1}	28.89	26.77	27.83	46.95	49.97	48.46	57.46	55.57	56.52
T_6	RDF + zinc @ 4 kg ha^{-1}	29.35	27.87	28.61	47.99	51.63	49.81	59.55	56.9	58.23
T_7	RDF + boron @ 1 kg ha^{-1}	28.46	27.31	27.89	46.12	46.43	46.28	56.02	53.03	54.53
T_8	RDF + boron @ 1.5 kg ha^{-1}	29.30	28.10	28.70	47.42	50.05	48.74	58.52	56.97	57.75
T_9	RDF + sulphur @ 20 kg ha^{-1} + zinc @ 2 kg ha^{-1} + boron @ 1 kg ha^{-1}	32.70	32.78	32.74	52.47	54.08	53.28	63.17	61.13	62.15
T_{10}	RDF + sulphur @ 30 kg ha^{-1}+ zinc @ 4 kg ha^{-1} + boron @ 1.5 kg ha^{-1}	34.03	33.40	33.71	53.88	55.18	54.53	64.57	62.2	63.39
	CD at 5%	2.96	2.53	2.68	3.23	4.03	3.53	4.17	4.03	4.06
	S.Em ±	1.03	0.88	0.95	1.12	1.40	1.26	1.45	1.40	1.42

Table 2: Number of leaves per plant of onion as influenced by different levels of sulphur, zinc and boron.

Treatments		30 DAT			60 DAT			90 DAT		
		2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1	Control (C)	5.22	4.95	5.09	8.07	7.62	7.85	8.48	8.13	8.31
T_2	RDF	6.30	6.10	6.20	8.18	7.99	8.09	8.73	8.25	8.49
T_3	RDF + sulphur @ 20 kg ha^{-1}	6.79	6.59	6.69	8.20	8.35	8.28	9.09	8.70	8.90
T_4	RDF + sulphur @ 30 kg ha^{-1}	7.11	6.91	7.01	8.50	8.4	8.45	9.25	9.07	9.16
T_5	RDF + zinc @ 2 kg ha^{-1}	7.07	6.83	6.95	8.36	8.22	8.29	9.27	9.09	9.18
T_6	RDF + zinc @ 4 kg ha^{-1}	7.45	7.30	7.38	8.61	8.52	8.57	9.42	9.36	9.39
T_7	RDF + boron @ 1 kg ha^{-1}	6.99	6.79	6.89	8.41	8.29	8.35	9.31	9.22	9.26
T_8	RDF + boron @ 1.5 kg ha^{-1}	7.30	7.10	7.20	8.88	8.8	8.84	9.51	9.38	9.45
T_9	RDF + sulphur @ 20 kg ha^{-1} + zinc @ 2 kg ha^{-1} + boron @ 1 kg ha^{-1}	7.61	7.41	7.51	9.53	9.19	9.36	9.85	9.29	9.57
T_{10}	RDF + sulphur @ 30 kg ha^{-1}+ zinc @ 4 kg ha^{-1} + boron @ 1.5 kg ha^{-1}	7.74	7.58	7.66	9.75	9.53	9.64	10.11	10.27	10.19
	CD at 5%	0.38	0.41	0.39	0.28	0.23	0.28	0.37	0.35	0.32
	S.Em ±	0.13	0.14	0.13	0.10	0.08	0.09	0.13	0.12	0.11

Table 3: Leaf length (cm) of onion as influence by different levels of sulphur, zinc and boron.

Treatments		30 DAT			60 DAT			90 DAT		
		2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1	Control (C)	19.83	18.93	19.38	27.68	25.20	26.44	35.50	32.78	34.14
T_2	RDF	20.04	19.06	19.55	30.10	25.28	27.44	36.58	34.58	35.58
T_3	RDF + sulphur @ 20 kg ha^{-1}	21.44	20.71	21.08	31.03	26.90	28.96	38.02	35.78	36.90
T_4	RDF + sulphur @ 30 kg ha^{-1}	23.29	21.77	22.53	32.82	27.51	30.17	39.76	36.58	38.17
T_5	RDF + zinc @ 2 kg ha^{-1}	21.38	20.26	20.82	32.61	29.82	31.22	37.52	36.64	37.08
T_6	RDF + zinc @ 4 kg ha^{-1}	22.50	21.27	21.89	34.21	30.90	32.43	38.42	37.86	38.14
T_7	RDF + boron @ 1 kg ha^{-1}	21.81	20.53	21.17	31.91	30.99	31.45	37.97	36.91	37.44
T_8	RDF + boron @ 1.5 kg ha^{-1}	22.89	21.41	22.15	33.18	32.12	32.65	39.87	38.57	39.22
T_9	RDF + sulphur @ 20 kg ha^{-1} + zinc @ 2 kg ha^{-1} + boron @ 1 kg ha^{-1}	24.52	23.57	24.04	36.20	33.66	34.93	42.17	41.28	41.73
T_{10}	RDF + sulphur @ 30 kg ha^{-1}+ zinc @ 4 kg ha^{-1} + boron @ 1.5 kg ha^{-1}	25.14	24.62	24.88	37.53	35.76	36.65	43.30	42.54	42.92
	CD at 5%	2.96	2.53	2.68	4.03	3.23	4.03	4.17	3.96	4.03
	S.Em ±	1.03	0.88	0.95	1.40	1.12	1.40	1.45	1.40	1.40

Table 4: Effect of different levels of sulphur, zinc and boron on yield and yield components of onion.

Treatments		Bulb length (cm)			Bulb diameter (cm)			Weight of bulb (g)			Bulb yield/plot (kg)			Bulb yield/hectare (t ha^{-1})		
		2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1	Control (C)	4.29	4.11	4.20	4.59	4.19	4.39	63.10	59.54	61.32	19.10	18.01	18.56	18.60	15.86	17.23
T_2	RDF	4.82	4.37	4.60	5.16	4.57	4.87	68.26	62.42	65.34	23.57	21.49	22.53	23.49	21.67	22.58
T_3	RDF + sulphur @ 20 kg ha^{-1}	5.30	5.20	5.25	5.82	5.56	5.69	75.62	70.53	73.08	26.80	25.55	26.18	25.99	24.73	25.36
T_4	RDF + sulphur @ 30 kg ha^{-1}	5.39	5.35	5.37	5.95	5.88	5.92	77.77	73.53	75.65	29.70	27.83	28.77	26.14	26.18	26.16
T_5	RDF + zinc @ 2 kg ha^{-1}	5.32	5.26	5.29	5.84	5.75	5.80	76.92	71.54	74.23	28.34	27.15	27.75	26.21	24.35	25.28
T_6	RDF + zinc @ 4 kg ha^{-1}	5.38	5.34	5.36	5.94	5.83	5.89	77.54	74.98	76.26	29.41	28.70	29.06	27.17	25.45	26.31
T_7	RDF + boron @ 1 kg ha^{-1}	5.31	5.25	5.28	5.85	5.69	5.77	76.32	74.84	75.58	27.51	28.51	28.01	26.37	25.69	26.03
T_8	RDF + boron @ 1.5 kg ha^{-1}	5.36	5.27	5.32	5.92	5.84	5.88	77.38	75.56	76.47	29.45	29.02	29.24	27.11	26.97	27.04
T_9	RDF + sulphur @ 20 kg ha^{-1} + zinc @ 2 kg ha^{-1} + boron @ 1 kg ha^{-1}	6.08	5.72	5.90	6.52	6.43	6.48	83.67	81.97	82.82	33.62	32.01	32.82	31.11	28.19	29.65
T_{10}	RDF + sulphur @ 30 kg ha^{-1}+ zinc @ 4 kg ha^{-1} + boron @ 1.5 kg ha^{-1}	6.27	6.15	6.21	6.60	6.61	6.61	85.73	82.76	84.25	34.40	33.44	33.92	31.28	29.10	30.19
	CD at 5%	0.45	0.51	0.47	0.42	0.50	0.46	4.01	4.48	4.24	2.84	3.55	3.10	2.06	2.71	2.39
	S.Em ±	0.15	0.18	0.16	0.14	0.17	0.16	1.37	1.54	1.45	0.97	1.22	1.09	0.71	0.93	0.82

Bulb length and bulb diameter (cm)

Bulb length and bulb diameter of onion was significantly influenced by sulphur, zinc and boron levels in both the years (2020 and 2021). Significantly higher bulb length (6.21 cm) and bulb diameter (6.61 cm) was recorded with application of 30 kg S ha^{-1}, 4 kg Zn ha^{-1} and 1.5 kg B ha^{-1} (T_{10}) along with recommended dose of fertilizers as compare to other treatments. However, it was on par with 20 kg S ha^{-1}, 2 kg Zn ha^{-1} and 1 kg B ha^{-1} (T_9) and significantly lowest bulb length (4.20 cm) and bulb diameter (4.39 cm) was noticed in control (T_1). Significant increase in bulb length and bulb diameter values due to increase in application of sulphur, zinc and boron. This may be due to boron and zinc enhances the enzyme activity which in turn trigger the physiological process like protein and carbohydrate metabolism in plants and sulphur performs many physiological functions like synthesis of sulphur containing amino acids. This lead to faster synthesis and translocation of photosynthates from source (leaves) to sink (bulb). This in turn increases the length and diameter of the onion bulb. These results were in conformity with Lal and Maurya (1981), Aske *et al*. (2017) [3].

Bulb weight (g $plant^{-1}$)

Application of different levels of sulphur, zinc and boron had significant effect on weight of the bulb in both the years (2020 and 2021). Significantly higher bulb weight (84.25 g $plant^{-1}$) was recorded in application of 30 kg S ha^{-1}, 4 kg Zn ha^{-1} and 1.5 kg B ha^{-1} (T_{10}) along with recommended dose of fertilizers as compare to other treatments, which was on par with 20 kg S ha^{-1}, 2 kg Zn ha^{-1} and 1 kg B ha^{-1} (T_9, 82.82 g) and significantly lower bulb weight (61.32 g $plant^{-1}$) was recorded in control (T_1). The treatment T_{10} was significantly superior over all other treatments. This may be due to sulphur, zinc and boron play an important role in plant growth through the biosynthesis of endogenous hormones which is responsible for promotion of plant growth and role in cell division, meristematic activity of plant tissue and expansions of cells. This in turn results in higher individual weight of the bulb. The results are similar to Bhatt *et al.* (2004) [4].

Bulb yield per plot (kg) and Bulb yield per ha (t ha^{-1})

The bulb yield of onion per plot and bulb yield of onion per hectare was significantly influenced by sulphur, zinc and boron levels in both the years (2020 and 2021). Significantly maximum bulb yield per plot (33.92 kg) and bulb yield per hectare (30.19 t ha^{-1}) was observed with application of 30 kg S ha^{-1}, 4 kg Zn ha^{-1} and 1.5 kg B ha^{-1} (T_{10}) which was found on par with application of 20 kg S ha^{-1}, 2 kg Zn ha^{-1} and 1 kg B ha^{-1} (T_9). while, minimum bulb yield per plot (18.56 kg) and bulb yield per hectare (17.23 t ha^{-1}) of onion was recorded in control (T_1). Significant increase in bulb yield per plot and bulb yield per hectare with increase in application of sulphur, zinc and boron levels which was attributed to higher dry matter accumulation in bulbs would ensure higher individual bulb weight and larger bulb diameter (Table 4) which collectively increased the bulb yield of onion and also higher photosynthetic efficiency of onion that resulted in more photosynthates must translocated to the bulb, realizing in higher bulb yield. These results are in accordance with the findings of Bhupendra and Prabhakar (2012) [5], Ram and Katiyar (2013) [13].

Quality parameters

The pooled data of 2020 and 2021 on quality parameters of onion as affected by sulphur, zinc and boron levels are presented in table 5.

Table 5: Effect of different levels of sulphur, zinc and boron on quality parameters of onion.

	Treatments	Total soluble solids (⁰Brix)			Ascorbic acid (mg 100 g^{-1})			Protein content (%)		
		2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1	Control (C)	10.18	8.98	9.58	7.91	7.17	7.54	9.45	9.23	9.34
T_2	RDF	11.55	10.60	11.08	9.09	8.35	8.72	10.95	10.73	10.84
T_3	RDF + sulphur @ 20 kg ha^{-1}	12.93	11.55	12.24	10.31	8.99	9.65	12.54	12.00	12.27
T_4	RDF + sulphur @ 30 kg ha^{-1}	13.16	11.78	12.47	11.00	10.16	10.58	13.10	12.56	12.83
T_5	RDF + zinc @ 2 kg ha^{-1}	12.96	11.91	12.44	10.38	9.60	9.99	13.15	12.51	12.83
T_6	RDF + zinc @ 4 kg ha^{-1}	13.17	12.02	12.60	10.97	10.13	10.55	13.46	12.82	13.14
T_7	RDF + boron @ 1 kg ha^{-1}	12.46	12.22	12.34	10.39	9.91	10.15	12.95	12.66	12.81
T_8	RDF + boron @ 1.5 kg ha^{-1}	12.90	12.29	12.60	10.95	10.17	10.56	13.39	13.09	13.24
T_9	RDF + sulphur @ 20 kg ha^{-1} + zinc @ 2 kg ha^{-1} + boron @ 1 kg ha^{-1}	14.73	14.61	14.67	13.37	12.07	12.72	15.05	14.52	14.79
T_{10}	RDF + sulphur @ 30 kg ha^{-1}+ zinc @ 4 kg ha^{-1} + boron @ 1.5 kg ha^{-1}	15.94	14.82	15.38	14.49	12.25	13.37	15.52	14.83	15.18
	CD at 5%	0.94	1.07	1.00	0.76	0.74	0.88	0.88	0.60	0.71
	S.Em ±	0.32	0.37	0.34	0.26	0.25	0.30	0.30	0.21	0.25

Total soluble solids (TSS) (ºBrix) and Ascorbic acid (mg 100 g^{-1}) content

TSS and ascorbic acid content in onion bulbs after harvest was significantly influenced by sulphur, zinc and boron levels in both the years (2020 and 2021). Significantly highest TSS (15.38 ºBrix) and ascorbic acid content (13.37 mg 100 g^{-1}) was found with application of 30 kg S ha^{-1}, 4 kg Zn $ha^{-1}$and 1.5 kg B ha^{-1} (T_{10}) which was on par with 20 kg S ha^{-1}, 2 kg Zn ha^{-1} and 1 kg B ha^{-1} (T_9, 14.67 ºBrix, 12.72 mg 100 g^{-1}) and significantly lowest TSS (9.58 ºBrix) and ascorbic acid content (7.54 mg 100 g^{-1}) was found in control (T_1). The increase in quality parameters in onion bulbs with application sulphur, zinc and boron levels was attributed to higher sulphur and zinc uptake as primary flavour compounds in onion are sulphur containing organic compounds. Higher sulphur uptake and application enrich the bulbs with sulphur which is responsible for increase in synthesis of volatile sulphur compounds and production of more pungency in onion and application of micronutrients might be attributed to enhanced metabolic processes involved in biosynthesis of total soluble solids, such as carbohydrates organic acid, amino acid and other inorganic constituents (Acharya *et al.*, 2015) [1]. Lal and Maurya (1981) [10] also stated that increased carbohydrates production during the process of photosynthesis and both zinc and boron play a vital role in photosynthetic activity of plant. The present results also corroborate with Prusty *et al.* (2020) [12] in onion.

Protein content in bulb (%)

Protein content in onion bulbs after harvest was significantly influenced by sulphur, zinc and boron levels in both the years (2020 and 2021). The protein content in onion bulbs varied from 9.34% to 15.18% in different treatments. Significantly highest protein content in onion bulbs (15.18%) was found in application of 30 kg S ha^{-1}, 4 kg Zn ha^{-1} and 1.5 kg B ha^{-1} (T_{10}) which was on par with 20 kg S, 2 kg Zn and 1 kg B ha^{-1} (T_9, 14.79%) and the lowest protein content in onion bulbs was found in control (T_1, 9.34%). The increase in protein content on sulphur, zinc and boron application might be attributed to increase in the activity of enzymes involved in protein synthesis on its addition. This increase in protein yield may be attributed to higher production of bulbs and improvement in protein percentage with Zn and B addition and application of sulphur leads to higher protein contents in onion (Rizk *et al.*, 2012) [15].

Economics

The pooled data of 2020 and 2021 on economics of onion as affected by sulphur zinc and boron levels at harvest are presented in Table 6.

Among the all treatments, significantly highest gross returns (₹483040 ha^{-1}), net returns (₹395626 ha^{-1}) and B:C ratio (5.53) was found in treatment which receive 30 kg S ha^{-1}, 4 kg Zn ha^{-1} and 1.5 kg B ha^{-1} (T_{10}) followed by marginal decrease in gross returns (₹474400 ha^{-1}), net returns (₹387681 ha^{-1}) and B:C ratio (5.47) with application of 20 kg S ha^{-1}, 2 kg Zn ha^{-1} and 1 kg B ha^{-1} (T_9) and lowest gross returns (₹275680 ha^{-1}), net returns (₹211080 ha^{-1}) and B:C ratio (4.27) observed under control plot (T_1). The highest net returns and B:C ratio recorded with 30 kg S ha^{-1}, 4 kg Zn ha^{-1} and 1.5 kg B ha^{-1} (T_{10}) was attributed to higher bulb yield (Table 4) resulting in highest gross returns (₹483040 ha^{-1}). Similar results were also reported by Bhupendra and Prabhakar (2012) [5] and Smriti *et al.* (2002) [18].

Table 6: Effect of different levels of sulphur, zinc and boron on economics of onion cultivation.

Treatments		Cost of cultivation (₹ ha^{-1})			Gross return (₹ ha^{-1})			Net return (₹ ha^{-1})			B:C Ratio		
		2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
T_1	Control (C)	64350	64850	64600	297600	253760	275680	233250	188910	211080	4.62	3.91	4.27
T_2	RDF	85229	85729	85479	375840	346720	361280	290611	260991	275801	4.41	4.04	4.23
T_3	RDF + sulphur @ 20 kg ha^{-1}	86229	86729	86479	415840	395680	405760	329611	308951	319281	4.82	4.56	4.69
T_4	RDF + sulphur @ 30 kg ha^{-1}	86729	87229	86979	418240	418880	418560	331511	331651	331581	4.82	4.80	4.81
T_5	RDF + zinc @ 2 kg ha^{-1}	85379	85879	85629	419360	389600	404480	333981	303721	318851	4.91	4.53	4.72
T_6	RDF + zinc @ 4 kg ha^{-1}	85529	86029	85779	434720	407200	420960	349191	321171	335181	5.08	4.73	4.91
T_7	RDF + boron @ 1 kg ha^{-1}	85319	85819	85569	421920	411040	416480	336601	325221	330911	4.95	4.79	4.87
T_8	RDF + boron @ 1.5 kg ha^{-1}	85364	85864	85614	433760	431520	432640	348396	345656	347026	5.08	5.03	5.05
T_9	RDF + sulphur @ 20 kg ha^{-1} + zinc @ 2 kg ha^{-1} + boron @ 1 kg ha^{-1}	86469	86969	86719	497760	451040	474400	411291	364071	387681	5.76	5.19	5.47
T_{10}	RDF + sulphur @ 30 kg ha^{-1} + zinc @ 4 kg ha^{-1} + boron @ 1.5 kg ha^{-1}	87164	87664	87414	500480	465600	483040	413316	377936	395626	5.74	5.31	5.53

Conclusion

Based on the results obtained under present investigation, it can be concluded that soil application of sulphur (20 kg ha^{-1}) through bentonite sulphur @ 22 kg ha^{-1}, zinc (2 kg ha^{-1}) through zinc sulphate @ 9.5 kg ha^{-1} and boron (1 kg ha^{-1}) through borax @ 9.5 kg ha^{-1} along with recommended dose of fertilizers was found significantly superior not only in increasing the bulb yield but also improved quality and economics of onion bulb.

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